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## METEOROLOGY

### ACADEMICIAN OBUKHOV DISCUSSES EARTH'S CLIMATE

Moscow ZEMLYA I VSELENNAYA in Russian No 4, Jul-Aug 82 pp 51-52

[Interview with A. M. Obukhov, academician, director, Institute of Physics of the Atmosphere, USSR Academy of Sciences, by E. K. Solomatina; date and place not specified]

[Text] An All-Union Symposium "Physical Aspects of the Theory of Climate" was held in late March 1982 in Moscow. About 200 representatives of the scientific research institutes of the USSR Academy of Sciences, Hydrometeorological Center, Main Geophysical Observatory, Central Aerological Observatory, Moscow State University and other scientific institutions of the country over the course of eight days discussed modern problems of climatic research. The principal directions in the work of this major forum of meteorologists, physicists and mathematicians, who are working in the field of study of climate were: physics of the climatic system; modeling of climatic processes; statistics of climatic fields. Some of the reports presented at the symposium will be published in immediately forthcoming numbers of our journal.

Academician A. M. Obukhov, director of the Institute of Physics of the Atmosphere, USSR Academy of Sciences, chairman of the organizing committee of the symposium, answered questions from a ZEMLYA I VSELENNAYA correspondent.

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[Question] During recent decades there has been a new approach to the study of the earth's climate. What is the nature of this new approach?

[Answer] If a brief answer is to be given, the specific character of study of climate in the present stage is that the earth's atmosphere and the world ocean are now regarded as a unified physical system. Such an approach was not known earlier in the science of climate, which studied the atmosphere and ocean independently of one another. Much attention is now also being devoted to a quantitative description of the diverse relationships among the links of this complex system and modern computers are being actively employed. There has also been an increase in the technical outfitting of observation systems -- scientific research ships, special automatic sounding balloons transmitting information by radio, floating buoys and satellite systems. At the same time the former observation systems continue to operate: meteorological stations supplied with thermometers and other instruments. They have still retained

their importance although the information which they provide is already inadequate.

[Question] In a number of reports presented at the symposium there was mention of the World Climate Program, adopted in 1979 at Geneva. What are its goals and how is work being carried out under this program?

[Answer] There has long been international cooperation among meteorologists. Weather forecasting is impossible without an exchange of observational data. But in the field of study of climate until recently it has essentially involved only an exchange of climatic reference books issued in different countries. Now the situation has substantially changed. In order to understand the mechanism of formation of climate and the reasons for its changes, including those caused by human activity, there is a need for far closer contacts between scientists and the development of many forms of international cooperation. The World Climate Program, adopted three years ago at the World Climate Conference in Geneva, pursues specifically these goals. The program provides for combined efforts in implementing the most costly and complex observation programs, defines the methods for the exchange of data even before their publication, and what is also very important, within the framework of this program series of international symposia are planned and organized which are devoted to the solution of key problems in the study of climate.

After the Geneva Conference a permanent coordination committee was established for linking the International Council of Scientific Unions and the World Meteorological Organization. In its work the committee relies on the headquarters secretariat of the WMO in Geneva. The annual sessions of the committee with the participation of specialists from many countries are held in different cities of the world. The last was held early in March of this year in Dublin. G. S. Golitsyn, corresponding member, USSR Academy of Sciences, and Professor M. A. Petrosyants are among the Soviet scientists in the coordination committee.

The final goal of the investigations carried out under the World Climate Program is the formulation of scientifically sound recommendations on how to make best use of the patterns of climate in the interests of mankind and how to prevent the undesirable consequences of an anthropogenic effect on climate.

[Question] What is the role of Soviet investigations in study of the earth's climate?

[Answer] It is completely natural that the scientists of our enormous country, occupying a sixth of the land mass of our planet, have taken and are taking a most active part in all meteorological projects, including the World Climate Program. This is done on the basis of friendly relationships with scientists of other countries. Use is made of the attainments in Soviet research techniques. Suffice it to mention that a third of all the scientific research ships engaged in international projects are Soviet scientific ships. With respect to the volume of work done within the framework of the recently completed First Global Experiment our country occupied one of the leading places in the world (ZEMLYA I VSELENNAYA, No 2, pp 47-50, 1980. -- Editor).

[Question] You mentioned the problem of the anthropogenic (associated with man's activity) effect on climate, which is causing scientists concern. What did the symposium give which was new in this respect?

[Answer] This problem was not dealt with separately at the symposium. It is a subject which requires a wider audience which includes not only meteorologists, but also specialists in the field of power, chemistry, medicine and ecology. It is possible that such a discussion can be held in the not distant future. However, at the symposium there were reports which gave results which undoubtedly will be useful in a discussion of the anthropogenic effect on the earth's climate. A number of reports considerably refined the "coefficients" necessary for computing different changes in climatic characteristics as a result of contamination of the atmosphere by carbon dioxide and some other gas components, as well as very fine suspended particles -- aerosols.

[Question] How do you evaluate the results of the symposium? Have scientists come closer to a solution of the problem of prediction of climatic changes?

[Answer] I feel that in some aspects of study of climate, such as in the problem of the anthropogenic effect on climate, we have undoubtedly come closer to a solution of the problem of prediction of climatic changes. But for a final solution there is still much which remains to be done. One of the most immediate problems is the most complete use of the enormous volume of scientific information which is already available to scientists in order to improve the proposed climatic models and select from these those which agree best of all with the observational data. Many reports were devoted to the modeling of climate. In evaluating the results of the symposium I would also like to note that a number of the discussed problems were related not only to the problem of climate, but also with the improvement of weather forecasts, especially long-range forecasts. Very frequently such a forecast is made without allowance for climatic patterns, and today this is inadequate. In solving these problems it is necessary to use modern statistical methods for study of atmospheric processes. These were also discussed at the symposium.

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ONE-DIMENSIONAL ATMOSPHERIC MODEL AS BLOCK IN OCEAN-ATMOSPHERE-ICE CLIMATIC SYSTEM

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian Vol 18, No 10, Oct 82 (manuscript received 30 Sep 81, after revision 27 Jan 82) pp 1011-1017

VERBITSKIY, M. Ya. and CHALIKOV, D. V., Institute of Oceanology, USSR Academy of Sciences

[Abstract] The reproduction of long-range climatic changes at present is possible only on the basis of simplified models which include all three principal climatic components (ocean-atmosphere-ice). A nonlinear model of evolution of continental glaciation intended for study of climate variations has already been published by Verbitskiy (DOKL. AN SSSR, Vol 256, No 6, pp 1333-1337, 1981). This article defines an atmospheric model based on heat and moisture transfer equations, averaged for circles of latitude and the vertical coordinate. The new model is closest to that published by B. Saltzman in GARP PUBL. SER., Vol 2, No 22, pp 803-841, 1979, but that is applicable only for the northern hemisphere atmosphere, the position of the ice sheets is fixed and the ocean is only very approximately taken into account. The mathematical model is outlined and it is shown how it can be used in reproducing the present-day mean annual regime of the atmosphere. The sensitivity of the model is investigated with respect to changes in the mean temperature of the continents, changes in temperature of the continents at the north and south poles, changes in mean atmospheric temperature, changes in atmospheric temperature at the north and south poles, changes in precipitation on the continents and oceans, changes in the mean heat flux into the ocean. Finally, the seasonal variation is modeled. Work is presently proceeding on integrating the atmospheric model with the mentioned model of continental ice and a simplified model of the ocean. Figures 6, tables 2; references 8: 4 Russian, 4 Western.  
[17-5303]

## DEEP MOIST CONVECTION EQUATIONS INCLUDING MOISTURE PHASE TRANSITIONS

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian  
Vol 18, No 10, Oct 82 (manuscript received 23 Nov 81, after revision 4 Mar 82)  
pp 1018-1025

VUL'FSON, A. N., Hydrometeorological Center

[Abstract] An improved system of deep convection equations is proposed which takes the phase transition of moisture into account. The proposed equations differ from those already in use in that the corresponding boundary conditions have integrals for the conservation of momentum, vorticity, total moisture content, generalized entropy and energy. It is shown that which such boundary conditions, which are examined in detail, the total energy of the system of moist convection equations consists of the kinetic and potential energy, as well as some parameter which can be interpreted as condensation energy. The proposed system makes it possible to clarify the concept of a moist adiabatic temperature gradient and to explain the role played by condensation energy. All this is integrated into the system of equations (11)-(17), whose derivation and corollaries are given. In addition, in the system of equations there is a family of conservation integrals of the energy type. It is shown that in the presence of slab or axial symmetry the proposed form of the stationary equations of deep moist convection allows determination of the first integrals. References: 11 Russian, 10 Western.  
[17-5303]

## RECONSTRUCTING VERTICAL PROFILE OF OZONE DENSITY IN ATMOSPHERE FROM MEASUREMENTS OF SOLAR IR RADIATION ABSORPTION

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian  
Vol 18, No 10, Oct 82 (manuscript received 26 May 81, after revision  
18 Jan 82) pp 1043-1049

VANIN, N. V., GLASKO, V. B., ZHIGULEVA, I. S. and KHATTATOV, V. U., Moscow State University; Central Aerological Observatory

[Abstract] Numerical experiments were carried out for determining the vertical distribution of atmospheric ozone using an IR heterodyne radiometer developed at the Central Aerological Observatory. In the proposed method a multichannel radiometer situated at the earth's surface measures the spectrum of solar radiation passing through the entire atmosphere in the band 9.58  $\mu\text{m}$ . It is shown that a knowledge of the dependence of the absorption coefficient for a selected ozone line on pressure and temperature, and accordingly, on distance from the earth's surface, makes it possible to reconstruct the vertical ozone distribution on the basis of measurements of optical thicknesses.

at different frequencies lying within the limits of the investigated line contour. In the experiments use was made of different values of the radiometer parameters and the principal types of ozone distribution (tropical, temperate, polar). Particular attention is given to use of the regularization method for reconstructing the ozone profile, as well as determining the atmospheric ozone mass mixing ratio. These studies made it possible to formulate recommendations for modernization of the IR heterodyne radiometer. The set of ozone optical thicknesses measured with the instrument is adequate for obtaining a satisfactory approximation to the initial profile only in the altitude range 10-26 km. It was found that for reconstructing the vertical ozone profile to altitudes 60-70 km it is necessary to have 6 weighting functions whose maxima fall in the range of altitudes 10-60 km. When using the A. N. Tikhonov regularizing algorithm the optimum values of the regularization parameter are  $10^9$ - $10^{10}$  for a "smooth" profile and  $10^5$ - $10^6$  for a profile with a secondary maximum. In addition to increasing the number of sounding frequencies, in order to obtain the vertical ozone profile with an accuracy adequate for practical applications it is necessary to increase the accuracy in measuring the ozone optical thicknesses with the instrument. A 5% relative error in measuring the optical thicknesses of ozone causes a 20% error in reconstructing the ozone profile, whereas a 10% error in temperature causes a 10% error in reconstructing the profile. Figures 3; references 18: 9 Russian, 9 Western.

[17-5303]

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#### LIDAR IDENTIFICATION OF DROPLET AND CRYSTALLINE CLOUDS

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian Vol 18, No 10, Oct 82 (manuscript received 25 Dec 80, after revision 23 Dec 81) pp 1050-1056

SAMOKHVALOV, I. V. and SHAMANAYEV, V. S., Institute of Atmospheric Optics, Siberian Department, USSR Academy of Sciences

[Abstract] Lidars can be employed in the remote recognition of types of aerosol formations, especially clouds. Single-frequency polarization lidars measuring the depolarization  $Q$  of a reflected echo signal with plane polarization of the sounding radiation have come into the widest use. In this article, using double scattering theory, the authors give an analysis of experimental data on the polarization sounding of clouds and discuss the criteria necessary for identifying the phase composition of clouds, taking into account the peculiarities of their internal structure. It was found that the absolute depolarization value at the cloud boundary, depolarization gradient in the depth of the cloud and the time shift between the maxima of the polarized and depolarized signal components differ for droplet and crystalline clouds. The difference is inadequate for identifying the phase state of clouds on the basis of just one of these criteria due to the great

variability of states of the lidar-cloud system. It is demonstrated, however, that the simultaneous use of all three parameters makes possible a reliable differentiation of clouds with water and ice phase states. Such an approach, based on joint analysis of the three lidar echo signal parameters, is promising for a qualitative identification of aerosols of different types without direct solution of inverse problems in atmospheric optics. Figures 6, tables 1; references 16: 8 Russian, 8 Western.  
[17-5303]

UDC 551.515:551.52:551.510.42

WEATHER CONDITIONS AND RADIATION CHARACTERISTICS IN ATMOSPHERE DURING PERIOD OF IMPLEMENTATION OF ABASTUMANI BACKGROUND AEROSOL EXPERIMENT (AFAEKS-78) IN AUGUST 1978

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian Vol 18, No 8, Aug 82 (manuscript received 10 Feb 82) pp 804-812

VDOVIN, B. I., ISKANDAROVA, V. M. and NEZVAL', Ye. I., Main Geophysical Observatory; Abastumani Astrophysical Observatory; Moscow State University

[Abstract] The joint Soviet-American Abastumani Background Aerosol Experiment was carried out in 1979, having been preceded by the Soviet national experiment AFAEKS-78. The results of the two experiments have been integrated in three articles in this number of IZV. AN SSSR: FIZIKA ATMOSFERY I OKEANA (pp 804-812; pp 813-821; pp 822-839). The first describes meteorological conditions during the course of the experiment, without which an intelligent interpretation of its results is impossible. The second is devoted to study of the chemical composition of gas and disperse constituents important for the processes of finely disperse aerosol. The third summarizes the results of study of the disperse phase in situ and in samples. In the first article, after describing the synoptic and weather conditions during AFAEKS-78, the authors define characteristic periods with a constant weather regime. The anomalous nature of the weather during the course of the experiment is outlined. There was a distinct difference in the weather conditions observed during AFAEKS-78 and during the course of a similar experiment at Abastumani in 1975. The total content of ozone in the atmosphere is examined and data are given on the receipts of solar radiation both in the solar spectrum and in the ultraviolet  $\lambda < 380$  nm. Examples are given of the spectra of total and scattered radiation in the wavelength range 300-550 nm on days with different atmospheric turbidity conditions. Figures 1, tables 9; references 7: 5 Russian, 2 Western.  
[5-5303]



## OCEANOGRAPHY

### INTERVIEW ON EXPEDITION OF RESEARCH SHIP 'VITYAZ''

Riga SOVETSKAYA LATVIYA in Russian 9 Sep 82 p 4

[Interview with Andrey Arkad'yevich Aksenov, doctor of geographical sciences, deputy director, Institute of Oceanology, USSR Academy of Sciences, by Andrey Chernoshchek, APN correspondent]

[Text] The Soviet scientific research ship "Vityaz'" has recently returned from its most recent voyage. For three months scientists and specialists worked aboard this floating laboratory, studying unknown natural phenomena in the Atlantic Ocean and in the Caribbean Sea. Andrey Arkad'yevich Aksenov, doctor of geographical sciences, deputy director, Institute of Oceanology, USSR Academy of Sciences, a participant on the voyage, tells about it to Andrey Chernoshchek, APN correspondent.

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Introductory comments. The ocean is full of secrets and mysteries and the more it is studied by scientists, the more surprises they find. Our expedition was to carry out a number of scientific research programs. One of these -- biological -- pursued both scientific and practical goals. The biological resources potential of the ocean is enormous. It produces almost half the organic matter on our planet. Since the moment of appearance of mankind the ocean has served as a treasure house yielding its wealth in unlimited quantity -- fish and other gifts of the sea. Now, however, the ocean has begun to send signals of alarm, warning that its resources are not unlimited. Since the central parts of the open ocean were earlier considered "blue deserts," the vast majority of the world catch of fish was in coastal waters. As a result of the intensive, at times rapacious catching of fish, the fish reserves in these zones began to decrease sharply and some of its species began to disappear. These include the Peruvian anchovy, whose share in the world catch of the sea product in 1970 was still 22%, as well as the Californian sardine, herring, cod, haddock, mackerel, salmon and bass. In many regions things have gone so far that reports have begun to arrive concerning the complete disappearance of different species of fish. This has forced scientists to conduct a search for schools of fish in the open ocean and this has led to very important discoveries. It was found that there is no "blue desert" and everywhere there is vigorous life in the ocean. In the ocean there is an unusually interesting and still not understood process of active interaction between living and nonliving nature. For

example, at depths of more than 6000 m life was discovered which due to the pressure existing there had not even been postulated theoretically. Rare biological phenomena have been discovered in the eastern part of the Pacific Ocean. The abyssal creatures living there are fed by exhalations, that is, by receipts of matter from the bottom layers. These are volcanic, fluid and gaseous products. One would think that the existence of any living beings under such conditions should be highly insignificant, crippled and impoverished, but the opposite was found: gigantism is observed among mollusks and some other animals. Individual species of animals are several times larger than under ordinary conditions.

The depths of the ocean were earlier regarded as quiet, but it was found that gigantic movements of water occur in them. "Cyclones" and "anticyclones," eddies and currents exist there. There are physical and biological boundaries which serve as "road signs" by which commercial fish make their migrations. Enormous accumulations of fish have also been discovered over underwater rises and ridges.

We decided to find out what attracts the schools of fish to these mountains, whether they arrive from nearby coastal regions of the ocean or whether they live and multiply on the peaks of underwater mountains. The biological research program related not only to fish, but also to the bottom population of plankton -- the principal food of fish, fauna. Our expedition worked in the Atlantic Ocean on some rises of the Mid-Atlantic Ridge and on the Great Meteor seamount, whose peak was situated at a depth of 300 m.

[Question] The ocean is considered a "weather kitchen" where heat and cold, tropical showers and hurricanes, cyclones and anticyclones are "prepared." By studying the "recipes" for their "preparation" will it be possible in the future to make long-range weather forecasts?

[Answer] The second program of our research under the name "Razrezy" ("Profiles") was devoted to a study of this problem. We could say that we have learned how to make beautiful weather forecasts for a half-year, for a year or a longer period. But for the time being there are no methods for long-range weather forecasting, although attempts have been undertaken to do this. They have been based on measurement of interaction between the ocean and the atmosphere with the assistance of mathematical models. But this requires the registry of all the changes occurring over gigantic areas of the land and ocean surface. With respect to the land, the state of its atmosphere is traced by thousands of meteorological stations situated on the land. But how to monitor the ocean if it is impossible to establish a dense network of stations there?

Academician G. I. Marchuk advanced the idea of not investigating the entire ocean, but its key zones -- the energy-active regions exerting an influence on the circulation of warm flows. For example, in one of these active regions, let's say the Newfoundland region, a deep cyclone is formed, which after traveling a long distance determines the weather in Europe, in the European part of our country. Therefore, by registering the anomalous situation in this energy-active region, its path and evolution, it will be

possible to give a precise weather forecast over a long period. But the investigation of these phenomena began only very recently and for the time being we know of but few such key zones which exert an influence on definite sectors of the land.

[Question] What region of the Atlantic Ocean was selected by the expedition for implementing the "Razrezy" program?

[Answer] The scientific research ship "Vityaz'" worked in the so-called Bermuda Triangle, which has won itself a sorrowful reputation due to the great number of ships and aircraft which have experienced disaster there. The warm Gulf Stream flows here. It has already been investigated for not less than a hundred years, but a whole series of characteristics of this current have been studied very poorly.

Our expedition has studied the distribution of temperature on three profiles intersecting this current and its periphery. Although the work was done under difficult conditions, scientists were able to collect much interesting information which was processed on shipboard. As a result, data were obtained which gave a general picture of the dynamics of the Gulf Stream. In addition, new data were obtained on the current itself. For example, biologists studying the tiniest unicellular algae, plankton and microplankton discovered that they are a sort of indicator clearly defining the boundaries of the current. Some types of plankton are in the current itself; others are found near it; still others are in remote regions.

Investigations under this program indicated that the Gulf Stream is not only related to the thermal interaction of the ocean and atmosphere but somehow this interaction regulates the distribution of life in the ocean.

[Question] In the scientific research programs carried out by cosmonauts on board orbital stations much attention has been devoted to study of the ocean and space today is assisting scientists in unraveling its mysteries. Can the ocean assist in the study of space phenomena?

[Answer] Automatic and manned space stations are performing a good service in solving the problems with which we are faced. But the opposite is also true. The ocean is assisting scientists in studying some space phenomena, such as carrying out an investigation of cosmic radiations. The earth is bombarded by a great flux of high-energy particles which are of considerable interest for science. These particles penetrate the earth's crust, reaching very great depths. They can be studied on the land using special apparatus situated in deep shafts. However, the trapping and determination of these particles is very highly dependent on the surrounding relief and the structure of the rocks which the shaft penetrates. But water in this respect is ideal; it is homogeneous optically and is quite homogeneous in its physical properties. Our expedition was concerned with these investigations, which were carried out under the physics program. A special system, created by the scientists of the Physics Institute, USSR Academy of Sciences, was lowered to a depth from two to six kilometers. It also registered these effects. All the experiments carried

out in the ocean are making a contribution to implementation of the scientific project "Dyumant." Within the framework of this project there will be registry of the intensity and character of the cosmic radiation incident on the earth. The implementation of this project is a matter of the future and its realization in different abyssal regions of the ocean will give some idea concerning the entire field of space in which our planet rotates.

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CSO: 1865/206

## RESULTS AND PROSPECTS OF COOPERATIVE OCEANOLOGICAL RESEARCH

Moscow EKONOMICHESKOYE SOTRUDNICHESTVO STRAN-CHLENOV SEV in Russian No 7, Jul 82  
pp 6-10

[Article by Andrey Aksenov, doctor of geographical sciences, deputy director, Institute of Oceanology imeni P. P. Shirshov, USSR Academy of Sciences, director, Coordination Center]

[Text] Among the 18 most important scientific and technical problems, formulated under the Complex Program of Socialist Economic Integration, a number of problems were directly related to the ocean. These included the formulation of measures for the preservation of the environment, investigation of the seas and oceans for the purpose of using their mineral resources, and study of the chemical, physical, biological and other processes of the most important regions in the world ocean. In order to implement cooperation under the last of the mentioned problems (for brevity we will call it "World Ocean"), in 1971 five of the socialist countries concluded a special agreement, to which the Republic of Cuba later adhered. A coordination center, the practical organizer of cooperation -- was created on the basis of the Institute of Oceanology imeni P. P. Shirshov, USSR Academy of Sciences.

The countries participating in the agreement on multilateral scientific and technical cooperation are the People's Republic of Bulgaria, the German Democratic Republic, the Republic of Cuba, Polish People's Republic, Socialist Republic of Romania and the USSR. They developed a work program important both for the formulation of joint scientific research and for the practical application of their results in branches of the national economy associated with the sea.

The further development of investigations of the problem within the framework of the agreement required the satisfaction of definite conditions, the most important of which was a harmonious combination of the common interests of the countries and the national interests of each participating country. A proper evaluation of scientific potential and determination of the principal forms of participation of scientific institutes was of considerable importance. For this purpose during the first years the coordination center directed efforts to the development of a scientific and technical forecast in this field on the basis of a questionnaire directed to specialists. The purpose of this work was essentially as follows: ascertain the most important (priority) topics and aspects of specific investigations. A forecast was prepared in a relatively short time. About 150 scientists from five countries participated in the questionnaire, distributed in

several versions. On this basis it was possible to have a clearer formulation of the scientific research program.

The cooperation program consists of five principal directions devoted to the study of physical processes in the ocean, the formation of its bioproductivity, chemical processes and sedimentation, and also the development of apparatus for underwater investigations. Such a division, in somewhat modified form, has been adhered to virtually from the very beginning of the cooperation. However, steps have been taken for the purpose of eliminating duplication of scientific work: in particular, we ceased to be concerned directly with the problems of contamination of the ocean because they quite fully enter into the sphere of interests of the other coordination centers.

Within the limits of the major parts of the program it is possible to discriminate specific scientific themes. They are more "mobile" and some of them are constantly being revised at the annual sessions of delegates. The investigations carried out on this problem are for the most part of a fundamental character; their results are used later in the most different fields and increase the sum of our knowledge concerning the ocean. Only a few subjects, such as the combined use of sea water for freshening and obtaining valuable elements, are of a purely practical nature.

It was important that from the very beginning of work under the agreement the countries did not limit themselves to coordination of national research, but carried out joint scientific studies giving original results. These studies had the form of international experiments, expeditions and the activity of mixed scientific groups.

Major international experiments in which about 100 scientists from all the countries participating in the agreement took part were already carried out in 1973. An experiment for studying interaction between the atmosphere and sea in the coastal zone was organized in the Baltic Sea at the base of the Marine Observatory of Leipzig University. In this first joint study the scientists of Bulgaria, East Germany, Poland and the USSR were not only familiarized with the apparatus and methods used by their colleagues from the other countries, but also carried out parallel measurements, compared research methods and conducted broad fundamental discussions. In short, they worked as a unified scientific body, filled with enthusiasm and striving to a common goal. Thus began an atmosphere of comradeship and sincere friendship which with the passing years became a solid tradition.

An important stage in the scientific cooperation of these countries was the joint work on the Bulgarian shelf of the Black Sea on the use of underwater research methods in oceanology in 1973 and 1974. The Soviet sealab "Chernomor" was delivered to the neighborhood of Cape Maslen and the "Akademik L. Orbeli," a scientific research ship of the Institute of Oceanology, USSR Academy of Sciences, arrived. Investigations of marine physics and geology were carried out, as well as psychophysiological investigations related to the work regime of aquanauts.

Later a whole series of experiments was carried out at the shore bases of Poland and Bulgaria devoted to problems of practical importance involving the transport of sediments and the characteristics of waves in the coastal zone.

Joint long-range in situ ecosystem investigations were carried out in the coastal biological polygon near Sozopol in Bulgaria. Research ships making surveys of extensive regions of the sea usually participated.

Purely marine scientific expeditions also are organized. For example, in 1979 scientists from five countries on the well-known Soviet ship "Vityaz'" (this was one of its last voyages) studied the ecosystems of open regions of the Black Sea; the voyage yielded valuable material making necessary a new look at the processes transpiring in the sea.

Experience has shown that international experiments best ensure the concentration of scientific personnel and financial resources of the interested countries. In studies under integrated programs, including a broad range of observations, there is participation by dozens of scientific workers of Bulgaria, East Germany, Poland, Romania and the USSR, using the latest apparatus systems. In the implementation of the programs the entire international body of specialists is subdivided into international research teams. The operational direction of the experiments is by a Scientific and Technical Council consisting of a number of leading scientists and the overall coordination is by one of the leading specialists of the organizing country. The coordination center carries out scientific and organizational preparations. During the period of the experiment there is a scientific seminar at which scientists present reports devoted to the present status of knowledge on all the directions in experimental work.

After the completion of field work the processing and analysis of the collected material is carried out first by the national teams and then, in the final stage, in international teams, meetings of which are organized by the coordination center in one of the countries participating in the experiment. The concluding stage is a final seminar on the results of the experiment and the publication of a specialized collection of articles on the research materials.

Also among the important forms of cooperation are theoretical investigations under coordinated programs, international symposia and seminars, conferences of expert groups and conferences on the coordination of working plans, the publication of joint materials -- monographs and specialized collections of articles. There have now been dozens of such collections of articles and monographs, most of them devoted to highly important problems of the Baltic and Black Seas.

The more than 10 years of cooperation of the member countries of the Socialist Economic Bloc on the "World Ocean" problem has undoubtedly been an important period in the development of oceanological research. The results of scientific studies in the principal directions have received high marks from specialists in all the countries participating in the agreement and are quite well known.

In summarizing the results of the joint work it is necessary to emphasize the following chief attainments and characteristics of cooperation of scientists and specialists of the fraternal countries.

The investigations carried out within the framework of the problem considerably supplemented scientific knowledge in many fields of oceanology. In particular, we gained a deeper knowledge of the mechanisms of heat and mass

exchange between the sea and atmosphere. New data were obtained for constructing models of the ecosystem of the Black Sea. Specialists generalized and jointly analyzed the available results of national investigations of the bioproductivity and ecosystems of the Baltic Sea, for which they refined the patterns of distribution of individual components in the sedimentary strata. The information obtained as a result of the geological-geographical investigations in the Bulgarian sector of the Black Sea is making it possible to draw conclusions concerning the proper direction for the search for petroleum and gas on the continental terrace of the People's Republic of Bulgaria. An extensive program of physiological investigations associated with underwater dives and man's long-term presence under water was carried out.

The results of investigations yielded material for the solution of practical problems in the field of hydrometeorology, navigation, fishing, protection of water against contamination and hydraulic construction. A number of published studies had the nature of specific recommendations for organizations concerned with the national economy.

The program for joint investigations of the problem was refined and made more effective; at the present time it is thoroughly thought-out, not duplicating other programs of the member countries of the Soviet Economic Bloc and most fully corresponding to the national interests of the cooperating countries.

A flexible system for the planning of research work has been adopted into practice. This has been used in preparing five-year long-range plans and constantly correctable working plans for the coming two years: a preliminary two-year plan and a specific plan for the coming year. Due to the long period of time required for preparing for major experiments and expeditions such a system was highly effective.

There was a considerable increase in the scientific base used in joint research. An independent Institute of Marine Research and Oceanology was created in the Bulgarian Academy of Sciences, as well as a specialized group on ecology which was delegated the task of carrying out complex experimental studies for investigating the functioning of ecosystems in the coastal zone. The Bulgarian Academy of Sciences made a considerable contribution to the problem, constructing a unique experimental pier and a corresponding shore base in the neighborhood of the Kamchiya River, organizing an experimental base for investigating biology in the Sozopol region.

The multisided use of the experimental base of the Hydraulic Construction Institute of the Polish Academy of Sciences at Lebatovo is of great importance. There has been a considerable broadening of the Oceanology Division, Polish Academy of Sciences; it can be hoped that in the not distant future this division will be transformed into an institute.

The scientific research ships of Bulgaria, East Germany, Poland and the USSR regularly participate in the international experiments and expeditions.

In the course of the joint investigations quite stable relationships were established among the scientists of the cooperating countries. International teams of scientists were formed for solving specific problems. They carried



out work on different aspects of the research. A clear system for the work of these teams was developed. Such a team gives results for all countries from the formulation of the goals and tasks of the research through practical work on implementation of the cycle of research in the sea to the processing and generalization of the materials.

The excellent work of the international teams of scientists represents a great organizational achievement of cooperation of the countries of socialist economic cooperation. Precisely this circumstance in a very short time made it possible to obtain a number of important scientific results. The rates of scientific research in the cooperation have been accelerated by a factor of 4-5. In other words, the results which were obtained in 3-4 years might have been realized within the framework of a national program in approximately 10-12 years.

The coordination center has been very active in the field of training of personnel. Joint practical work at sea and in the laboratory, the organization of training sessions (more than 100 specialists) or training in graduate programs -- such are the diverse methods for relaying experience and knowledge to young scientists. In addition, during the time of cooperation the young scientists prepared a series of candidate's dissertations and there was an improvement in the general level of qualification of the entire body of scientists participating in the joint work.

Within the framework of cooperation a whole system was developed for the training and upgrading of scientific personnel and specialists, involving 41 scientific organizations, three of them base organizations.

Taking into account the noted trends, the immediate prospects for cooperation can be represented in the following form:

the concentration of joint investigations in selected coastal polygons in the Black and Baltic Seas, outfitted with modern oceanological equipment;

the development of investigations of the anthropogenic effect on all aspects of the marine medium (reference is not simply to contamination, but rather the broadest possible formulation of the problem);

completion of the next stage of joint research with the publication of a series of collective monographs on the Black and Baltic Seas, conforming to a uniform plan.

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CSO; 1865/4

## SYSTEM FOR MARINE GEOPHYSICAL SURVEY

Moscow PRAVDA in Russian 2 Oct 82 p 2

[Article by V. Il'ichev and A. Yanshin, academicians]

[Text] The broadening of multisided investigations of the world ocean for the purpose of effective use of its resources -- such a task has been assigned to Soviet science and industry by the 26th CPSU Congress. This requires the availability of modern sea equipment ensuring the possibility of the processing of an enormous flow of data directly to scientific research ships.

In the creation of such equipment a major contribution has been made by the "Yuzhmorgeologiya" Combine of the USSR Geology Ministry in collaboration with the scientists of Ryazan' and Leningrad colleges and the Institute of Oceanology imeni P. P. Shirshov, USSR Academy of Sciences. Reference is to an experimental navigational-geophysical complex for marine geophysical exploration based on an electronic computer ensuring an increase in the productivity of labor by a factor of 2-3 due to around-the clock implementation of geophysical observations and also automation of measurements and data processing. Scientists of the Hungarian People's Republic took an active part in solution of the problem.

The creative cooperation of Soviet and Hungarian scientists made it possible to design and introduce a highly productive marine automated on-board navigational-geophysical complex with the use of satellite navigation on the scientific research ships of the USSR Ministry of Geology, USSR Academy of Sciences and USSR Ministry of Health. This complex is called the "MARS."

The automation of investigations of the world ocean is complicated by the peculiarities of marine geophysics and experimental oceanology. These include the diversity of geophysical and oceanological parameters and the methods for measuring them. Data are collected from great areas over long time intervals and the results are processed directly at sea under complex programs. It is also desirable to achieve a compact and graphic representation of the measurement results.

The complexity is further aggravated by the specifics of marine conditions. The wind, waves and currents cause vibrations, rolling and drift of the ship. Increased humidity, a broad range of temperatures, aggressiveness of sea salt in the air and a limited number of technical personnel on board -- all this

imposes additional requirements on the operational characteristics of the apparatus and its reliability and makes it necessary to fabricate apparatus in a "sea" variant.

In the designing and introduction of the "MARS" scientists used a multisided approach to study of physical fields in the ocean in their interrelationship. The apparatus which they proposed made possible a considerable increase in the productivity and quality of marine geophysical investigations, obtaining valuable data on the geological structure of the floor of the seas and oceans. The reliability of study of structures of the sedimentary stratum has been increased.

Aboard the ship the "MARS" joins together a set of geophysical, oceanographic and navigational sensors (gravimeter, hydromagnetometer, seismic prospecting and seismocoustic apparatus, reception and display apparatus of satellite, radionavigational and radiogeodetic systems, echo sounders, logs, etc.), coupled to a system of on-board electronic computers. The arriving geological-geophysical and oceanographic data are subjected to routine processing with the feedout of the results to external recorders. This is at a real time scale with simultaneous registry on a magnetic carrier.

Now complexes of the "MARS" series have been installed on 12 scientific research ships of the USSR Ministry of Geology, USSR Academy of Sciences and the Ministry of the Gas Industry and they have been used in geophysical and oceanological investigations in the most different regions of the world ocean. The total economic effect has already exceeded 15 million rubles.

Under the conditions of the Barents Sea, where weather conditions made it possible to carry out investigations only during the short summer period, the "MARS" during 1980-1981 made it possible to carry out about 10,000 km of profiles and obtain important geological information. For the first time in Soviet practice the effective depth of the investigations was increased to 20 km under the sea floor. The large Barents sedimentary basin was outlined.

In the Black Sea the "MARS," with minimum expenditures, over the course of three years made it possible to investigate the entire area of its abyssal basin and this yielded valuable, and in a number of cases unique materials. In particular, a study was made of the structure of the Western Black Sea and Eastern Black Sea Depressions, and also the central Black Sea Rise, whose structure in many respects was not such as visualized earlier. On the basis of new factual data for the first time it was possible to reconstruct the history of the geological development of the Black Sea Depression during the course of the last 60 million years, constituting great scientific and practical interest from the point of view of evaluating the prospects for finding petroleum and gas in this basin.

Also productive were investigations in the Atlantic Ocean, in the regions of the Sierra Leone Rise, Somali Basin, and also in the West Australian Basin of the Indian Ocean.

A result of this work was the construction of a series of Soviet gravimagnetic, structural, bathymetric and tectonic maps serving as a basis for evaluating the possibilities for seeking and exploring mineral resources on the ocean floor.

The "MARS" made it possible, for the first time in the USSR, to begin seismic (for petroleum and gas), seismoacoustic (for ferromanganese nodules) complex geological-geophysical and oceanological investigations of the world ocean on a productive scale.

More than 30 Author's Certificates have been awarded for apparatus and its components, but most such innovations have been patented in the United States, West Germany and France.

The development and broad introduction of the "MARS" complex represents a considerable achievement of Soviet science and technology. Soviet marine geophysics has a real basis for being proud of these achievements. The creators have justifiably been recommended for award of the USSR State Prize.

It is noteworthy that leading scientists, engineers and designers from the institutes of the Ministries of Geology and the Gas Industry and USSR Academy of Sciences have been proposed for award of this prize. This harmonious union of science and practical work has become a guarantee of success.

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CSO: 1865/14

## CHARACTERISTICS AND IMPORTANCE OF FERROMANGANESE NODULES

Moscow ZEMLYA I VSELENNAYA in Russian No 4, Jul-Aug 82 pp 34-38

MURDMAA, I. O., candidate of geological and mineralogical sciences

[Abstract] Ferromanganese nodules have been transformed from a scientific curiosity to a practical problem. They constitute a fundamentally new type of mineral raw materials. The task of the future is to outline these deposits, calculate their reserves and prepare deposits for working. A search for such deposits must be made in the most promising regions, being found in the sedimentsphere. These nodules are found where the rate of accumulation of sediments is minimum (less than 1 mm per 1000 years). There seems to be no hypothesis which adequately explains their formation or distribution. One of the puzzling problems is why all the nodule fields seem

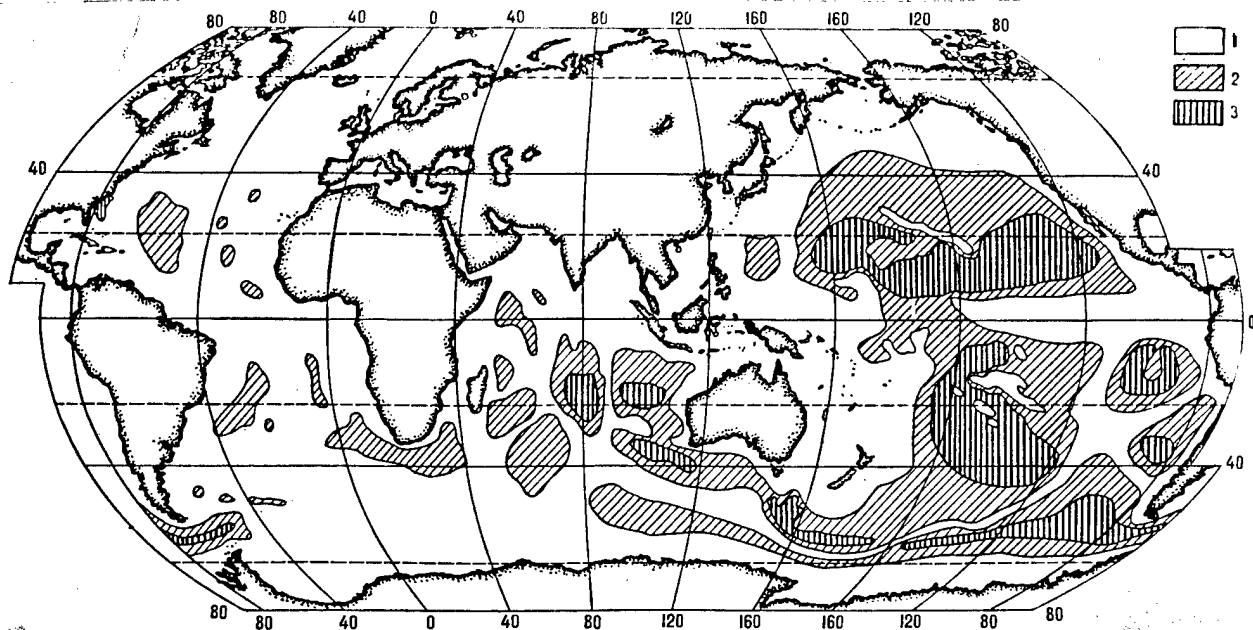


Fig. 1. Distribution of ferromanganese nodules on ocean floor.  
1) no nodules; 2) high concentrations infrequent; 3) high concentrations frequent.

to be of the same age. It is clear that they are associated with regions where sediments accumulate slowly. These areas are remote from the continents in the central pelagic regions of the Pacific and Indian Oceans which receive a minimum quantity of products of land erosion. The rates of sedimentation are minimum in latitudinally extended zones along both sides of the equator where biological processes are suppressed; the chief nodule fields are found in these areas. Nodules are rarely encountered along the equator, where the biological productivity of the waters increases. However, nodules are encountered only at great depths, below a definite critical depth or close to it. This depth is about 4.5-4.7 km. The specific characteristics of nodule fields must also be considered. There is a latitudinal zonality of composition. Those richest in manganese, nickel and copper are found in equatorial zones of siliceous radiolarian oozes, whereas those lying on pelagic clays to the north and south of these zones are richer in iron and contain a lesser quantity of nonferrous metals. The content of manganese, nickel, copper and molybdenum is greater in the nodules of abyssal plains, whereas iron and cobalt are largely associated with the nodules of underwater mountains and hills.

Figures 2.

[205-5303]

UDC 551.465+551.513

#### ATMOSPHERIC AND OCEANIC CIRCULATION

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ZEMLI in Russian No 6, Jun 82  
pp 94-100

MONIN, A. S., Institute of Oceanology imeni P. P. Shirshov, USSR Academy of Sciences

[Abstract] Synoptic processes (eddies and Rossby-Blinova waves) in the ocean and atmosphere are compared, it being stressed that in the ocean, as a result of less stable stratification, they have considerably lesser magnitude and velocity of movement and greater periods and lifetimes. The author is particularly interested in clarifying the role played by the ocean in the formation of climate. It is shown that climate is primarily a characteristic of the ocean; the atmosphere for the most part adapts to the state of the ocean and land (although the atmosphere does exert some influence on the land and ocean). In order to clarify this generalization the author examines the following: general circulation of the atmosphere; atmospheric synoptic processes; general circulation of the ocean; atmospheric stratification; scales of synoptic processes; oceanic synoptic processes. Synoptic movements in the ocean can be classified on the basis of the mechanisms of their formation as frontal--meanders in jet streams and rings (I) and free movements or eddies in the open ocean, generated by internal baroclinic instability (II), topographic effects (III) and atmospheric effects (IV). With respect to the direction of their rotation they can be classified as cyclonic (C) and anticyclonic (A). Further, they can be classified as eddies moving together with the water contained in them (E), and waves travelling through the water (W); in the latter case it is also possible to discriminate solitary waves or solitons (S). These

formations can also be distinguished by age. In contrast to the atmosphere, in which Rossby-Blinova waves are observed only in the form of isolated and rather rapidly attenuating trains, in the ocean they can form a far more developed wave field, a full description of which requires a quite complex spatial-temporal analysis. Like synoptic eddies in the atmosphere, eddies in the open ocean (types II, III, IV) evidently have a tendency to barotropization. Their ensemble, again by analogy with the atmosphere, acts on ocean jet currents as negative viscosity, imparting to them some of their kinetic energy by operation of the corresponding Reynolds stresses. Table 2; references 6: 4 Russian, 2 Western.  
[21-5303]

UDC 550.34.044; 551.463.28

COMPUTING ENERGY CHARACTERISTICS OF ACOUSTIC FIELD IN OCEAN FROM SEISMIC SOURCE UNDER EVEN BOTTOM CONDITIONS

Moscow VULKANOLOGIYA I SEYSMOLOGIYA in Russian No 3, May-Jun 82  
(manuscript received 17 Mar 81) pp 72-81

KADYKOV, I. F., Acoustics Institute, USSR Academy of Sciences

[Abstract] With registry of earthquake signals by hydrophones in addition to the first two phases in the signal caused by the arrival of P and S waves propagating in the earth's solid mantle there is a third phase (T phase) caused by the arrival of a hydroacoustic wave propagating in the water. An earthquake can give rise to hydroacoustic oscillations in different ways, with a marked difference in the intensity of the registered T phase; effective sound generation on sloping bottom sectors turned in the direction of the reception point and relatively weak sound generation on sectors with even bottom relief. Each case requires separate consideration. Sound generation by an even bottom is the more convenient for computing the acoustic field in the ocean. Although a rough evaluation of the change in a hydroacoustic signal (T phase) was made by R. H. Johnson, et al. (AGU, GEOPHYS. MONOGR., No 12, 1968), the results cannot be used for comparison with experimental data due to oversimplifications: no allowance was made for scattering of the acoustic wave front and energy loss during propagation in the water layer; the law of dropoff of seismic energy with distance was not substantiated. The author has therefore rectified these deficiencies. It is shown that the experimentally observed changes in the level of the T phase and the results of computations presented here can be used successfully in an approximate description of the temporal change in the level of a hydroacoustic signal caused by an earthquake when the T phase is formed in an area with an even bottom. In arriving at this conclusion the author used a coefficient of transformation of seismic energy into hydroacoustic energy which is identical for the entire bottom; averaged energy laws approximately reflecting the observed regularities were adopted for the geometrical scattering of wave fronts; the dependence of the absorption of seismic wave energy on distance was not taken into account. None of these simplifications appear to compromise the findings. Figures 8; references 13: 6 Russian, 7 Western.  
[18-5303]

## CORRELATION OF ATMOSPHERIC PRESSURE AND OCEAN LEVEL FIELDS ALONG SHORES OF KURILE ISLANDS

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian  
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27 Jul 81) pp 1077-1085

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[Abstract] The interrelationship of variations of atmospheric pressure and ocean level has been studied by many researchers, but contradictory results have been obtained. Accordingly, the author has examined the spectral-statistical characteristics of sea level slopes and atmospheric pressure gradients on the basis of observations of level and pressure on the ocean coast of the Kurile Islands. A nonmonotonic nature of the interrelationship of level and pressure is noted for the subtidal range in both time and space. A model of level variations under the influence of a wave of atmospheric pressure moving along the shore is examined. There are two types of response. There is a high-frequency type for which the characteristic time scale is some hours and it is primarily ordinary long waves (along the shore--edge waves) which play the primary role in the level formation. Such a response for moving lows along the shore is greater than static. The second type is a response to low-frequency pressure variations with a time scale greater than the inertial period; the response is less than static. Such low-frequency fluctuations can impart an appreciable part of their energy to shelf waves, Rossby waves or other types of horizontal transverse waves. The high-frequency response to a plane pressure wave normal to the shore in the coastal zone has a nonmonotonic character with increasing distance from the shoreline. Figures 4, tables 1; references 24: 12 Russian, 12 Western.  
[17-5303]

## NUCLEAR PHYSICS METHOD FOR DETERMINING DENSITY AND SALINITY OF SEA ICE

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian  
Vol 18, No 10, Oct 82 pp 1086-1090

FILIPPOV, Ye. M.

[Abstract] The need has arisen for developing speedy methods for determining the physical and chemical characteristics of sea ice, especially density and salinity. The presently used procedures are extremely time-consuming. The article describes a solution of this problem by application of the gamma-gamma method, in which the most commonly used radiation source is cesium-137; the sensor used is of the "Limon" type with a sodium iodide crystal, activated by thallium. This principle was applied in creating the GGP "Ays" gamma-gamma



densimeter for high-mountain glaciological research, later modified (GGM-S) for use at sea. A sensor supplied with detectors situated at a distance of 10 and 50 cm from the source will give information on ice density and salinity respectively with the necessary accuracy. Ice salinity in the course of 1 sec can be determined with relative errors of approximately 0.8%. Density can be ascertained with a relative error of about 0.4%. If the source activity is reduced by a factor of 100 (to  $10^8$  quanta/sec) these errors can be obtained with a duration of measurements 100 sec. Higher measurement accuracies can be obtained with a further increase in the duration of measurements. The brine content can also be determined. Since ice salinity and density, as well as the brine content, are dependent on ice temperature, all such investigations must be combined with ice thermometry. Figures 3, tables 2; references: 14 Russian.  
[17-5303]

UDC 551.463.5:535.36

#### SELF-SIMILAR THEORY OF MULTIPLE SMALL-ANGLE LIGHT SCATTERING AND ITS REFINEMENT

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERI I OKEANA in Russian Vol 18, No 8, Aug 82 (manuscript received 4 Aug 81) pp 840-849

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[Abstract] In the propagation of light beams in media with narrow scattering indicatrices and adequately great absorptivity the radiation field retains a strong anisotropy at any optical depths  $\tau$ . As a result, computations of its characteristics can be made with small-angle forms of the radiation transfer equation without any restrictions on the  $\tau$  parameter. In examining this general problem, the author has the following objectives: a more detailed exposition of the results of a diffusional self-similar theory with respect to the integral characteristics of the radiation field going beyond the framework of the diffusional approximation when computing these characteristics and a comparative analysis of the accuracy and limits of applicability of different "small-angle" solutions. This is accomplished by a detailed investigation of the integral characteristics of the stationary and nonstationary radiation fields with a highly elongated scattering indicatrix and sufficiently great absorptivity. The angular moments of the stationary radiation field are thoroughly examined in a series of approximations, followed by an investigation of characteristics of a pulsed signal. All this enabled the author to evaluate the accuracy and limits of applicability of the self-similar diffusional theory of multiple small-angle light scattering and to make it more precise. The self-similar theory can be used effectively in hydrooptics; this is illustrated in an example. Figures 4, tables 1; references 15: 14 Russian, 1 Western.  
[5-5303]

## LIGHT FIELD FLUCTUATIONS UNDER WAVE-COVERED SEA SURFACE

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian  
Vol 18, No 8, Aug 82 (manuscript received 18 Nov 80, after revision 3 Apr 81)  
pp 850-858

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Academy of Sciences

[Abstract] The authors derive expressions relating the spectral densities of signal fluctuations in a nondirectional photodetector, on the one hand, and the correlation functions of waves and the optical characteristics of water, on the other. These expressions are used in computing the spectra of fluctuations for different wind velocities over the surface, primary hydro-optical characteristics and photodetector parameters. The problem is formulated as follows. It is assumed that the wave-covered sea surface is illuminated by an infinitely wide flux of sun rays, whose angle of incidence as a simplification is assumed to be small. The investigation is limited to fluctuations caused by the focusing effect, neglecting fluctuations associated with random fluctuations of the optical paths of rays incident at the reception point. In this article consideration was given to only one mechanism for formation of fluctuations of the underwater light field associated with random focusing of the field of the wave-covered surface, for which numerical computations are given. However, it is necessary to clarify the role of other mechanisms, especially the magnitude of the fluctuations caused by random fluctuations of the optical paths. The described method allows a corresponding generalization and two such generalizations are presented. Figures 4; references 14: 11 Russian, 3 Western.  
[5-5303]

UDC 551.466.75

## INVESTIGATING WATER CIRCULATION IN SEA COASTAL ZONE

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian  
Vol 18, No 8, Aug 82 (manuscript received 12 Feb 81) pp 870-876

SHELKOVNIKOV, N. K. and RAKITINA, I. S., Moscow State University

[Abstract] During the period 1979-1980 instrumental measurements were made of current velocity and water temperature in the coastal zone of the sea. In addition, for a detailed study of the vertical structure of surge currents the authors made measurements of the mean and fluctuating components of current velocity in the laboratory for simulating shelf regions of the sea. The in situ work was done from an anchored ship and small boat. Aboard the ship two series of measurements were made with a duration of 7 and 9 days during which it was possible to ascertain the vertical profiles of water temperature and current direction and velocity, as well as to make meteorological

observations. Measurements of currents and water temperature in the sea zone between the ship and shore were made from the small boat. About 20 runs were made perpendicular to the shoreline. Current velocity was measured from both the ship and small boat each 2 m in depth. The vertical distribution of water temperature was determined by continuous sounding with resistance thermometers. This article stresses the surge currents observed in August 1980. A dependence of the coefficient of turbulent viscosity on depth is proposed for explaining the observed vertical profiles of mean current velocity. The development of the surge currents is fully explained on the basis of the combined in situ and laboratory data. Figures 4; references: 6 Russian. [5-5303]

UDC 551.466.31

#### INITIAL STAGE OF WIND WAVE DEVELOPMENT

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian Vol 18, No 8, Aug 82 (manuscript received 29 Jun 81) pp 889-892

POKAZEYEV, K. V. and VORONIN, L. M., Moscow State University

[Abstract] At present there is no unanimous opinion concerning the development of wind waves in the initial stage. The principal mechanisms which have been proposed are the Miles shear instability mechanism and the Phillips resonance mechanism. A limitation of the growth of waves in the initial stage probably occurs as a result of viscous dissipation, when the high-frequency components develop in several seconds; the stationary spectrum of surface waves, in the case of operation of the Phillips mechanism, is determined through the spectrum of pulsations of atmospheric pressure. In order to clarify this problem an experiment was carried out in which a study was made of the dependence of the amplitude of a wind wave on wind velocity and fetch. The experiment was carried out in a glass flume 6 m long, 60 cm wide and with a water depth of 20 cm; a wind flow was created whose velocity was varied in the range from 2 to 8 m/sec. The height of the air flow over the water was 10 cm. This made it possible to determine the dependence of the mean square oscillations of the surface and wind velocity. With respect to the dependence  $\sigma(V)$  it is noted that first there is a slow increase in oscillations of surface rises with an increase in wind velocity; then, after attaining a definite velocity, which is dependent on the fetch, there is a considerably more intense increase in the surface rises. The velocity at which there is a marked increase in the dependence of  $\sigma$  on  $V$  is the critical wind velocity value  $V_{cr}$ . It is concluded on the basis of this experiment that the critical velocity  $V_{cr}$  is dependent on fetch and that the dependence of the mean square surface oscillations on wind velocity has the form  $\sigma = A[(V - V_{cr})/V_{cr}]^{1/2}$ . Figures 4, tables 1; references 5: 4 Russian, 1 Western. [5-5303]

## CORRELATION BETWEEN MICROSCALE TURBULENCE AND THERMOCLINE DYNAMICS

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian  
Vol 18, No 8, Aug 82 (manuscript received 15 Oct 80, after revision 27 Jan 81)  
pp 892-893

MADERICH, V. S., Hydromechanics Institute, Ukrainian Academy of Sciences

[Abstract] One of the most important problems in the theory of the thermocline is the relationship of the processes of advection and turbulent mixing in maintaining the oceanic thermocline. Known solutions of the nonlinear equations of thermocline theory, however, do not cast sufficient light on this problem. It has been concluded that either in the thermocline (other than thin diffusion layers) there is a dominance of advective transfer or that the turbulent density fluxes are definitely consistent with advective transfer, but are not necessarily small. In order to clarify this problem the author investigated geostrophic circulation in a baroclinic ocean of variable depth. Nonstationarity is taken into account only in the density transfer equation, so that the initial equations describe the dynamics of long divergent non-dispersing Rossby waves. The upper limit of the region coincides with the depth of the friction layer at which there is stipulation of the vertical Ekman velocity  $w_e$  and turbulent density flux  $q_0$ . The problem is reduced to solution of one equation with two unknowns. On this basis an effort is made to find physically admissible solutions. The proposed method makes it possible to obtain new solutions describing a thermocline of finite depth or giving a hyperbolic law of distribution of density with depth. A peculiarity of the vertical distribution of  $q$  (vertical turbulent density flux) is that the corresponding coefficient of vertical diffusion  $\psi = q / (\partial^3 Q / \partial z^3)$  is a variable in the space of the functions  $w_e$  and  $q_0$ . The expressions for  $\psi$  in certain cases give an increase in  $\psi$  with depth, which contradicts the prevailing notion of a constancy of  $\psi$  with depth and a small role of diffusion in the deep layers of the ocean, but agrees with current data on small-scale turbulence. These peculiarities in the distribution of  $\psi$  are explained. The behavior of other thermocline parameters is also clarified. References: 3 Russian.  
[5-5303]

UDC 551.481:7.021.2

## PROGNOSTIC MODEL OF CURRENTS IN STRATIFIED WATER BODIES

Moscow OKEANOLOGIYA in Russian Vol 22, No 4, Jul-Aug 82 (manuscript received 22 Dec 81) pp 550-556

AKOPYAN, M. A. and DEMIN, Yu. L., Institute of Oceanology imeni P. P. Shirshov, USSR Academy of Sciences, Moscow

[Abstract] The authors proposed a nonlinear prognostic model based on primitive equations of motion which can be used for computations of currents in basins

situated both in the equatorial zone and in the middle latitudes. The problem is formulated and a numerical method for its solution is given. It is assumed that there is a closed water body with a real shoreline configuration and real bottom relief which is under the influence of a stationary wind and which has a stipulated water temperature at the surface. It is assumed that the coefficients of vertical and horizontal turbulent viscosity  $\nu$ ,  $A_L$  are equal to the corresponding heat diffusion coefficients  $\nu_T$ ,  $A_T$ . A solution of the theoretical system of equations is presented. These equations are used in specific computations for Lake Sevan. The study of this lake in theoretical models is particularly important because of its constantly changing level. With different states of its level such models make it possible to simulate its thermal and hydrodynamic characteristics and predict its optimum water level. In applying the model the lake was approximated by a three-dimensional grid region. The horizontal interval was 1 km. Vertically there were 17 computation horizons, with the last being at a depth of 60 m; the time interval was 10 minutes, both in the equations of motion and in the heat transfer equation. The proposed numerical scheme imposes relatively low requirements on the computer operational memory. Meaningful data were obtained on the formation of the fields of temperatures and currents in Lake Sevan. The maps plotted on this basis and other computed data are in good agreement with experimental observations. Figures 5, tables 1; references 12: 10 Russian 2 Western.  
[200-5303]

UDC 551.465.4

# STATISTICAL EVALUATIONS OF VELOCITIES OF ANTARCTIC CIRCUMPOLAR CURRENT IN PACIFIC OCEAN

Moscow OKEANOLOGIYA in Russian Vol 22, No 4, Jul-Aug 82 (manuscript received 17 Dec 80, after revision 12 Oct 81) pp 557-561

GRITSENKO, A. M., Institute of Oceanology imeni P. P. Shirshov, USSR Academy of Sciences, Moscow

[Abstract] Long-term statistical studies have been made of circulations of Pacific Ocean waters in the past, but these have been generally inadequate. The author has attempted to enhance the quality of such investigations. This article gives the results of studies of the zonal  $u$  and meridional  $v$  components of velocity of the Antarctic Circumpolar Current (ACC), computed from the density field on the basis of the Sarkisyan model. However, in contrast to statistical evaluations of each component of the vector separately, the author uses a bivariate empirical probability density function  $P(u, v)$  of the zonal and meridional components. This was done using pairs of  $u$  and  $v$  values at standard horizons in approximately 170  $5^\circ$  squares to the south of  $40^\circ\text{S}$ . The relief of the  $P(u, v)$  function for the ACC at the surface is characterized by a predominance of components of northerly and easterly directions and this  $P(u, v)$  relief extends in a northeasterly direction. This azonality of the ACC is attributable to the wind field at these latitudes, bottom relief and

the presence of continental barriers. With increasing depth the structure of the ACC experiences considerable changes. At a depth of 10 m both the relief of the  $P(u, v)$  function and the  $P(u)$  and  $P(v)$  distribution differ substantially from the pattern at the surface. The northerly and easterly components continue to predominate, but the fraction of components of the opposite direction increases. The azonality of the current is still further aggravated. The correlation coefficients  $r(u)$  and  $r(v)$  were computed for evaluating variability of structure of the ACC with depth. The  $u$  and  $v$  current components were correlated at the surface and at underlying standard horizons to 4000 m. The influence of the drift component was excluded and the variability of the geostrophic component was ascertained. The greatest variability was characteristic of the surface horizons, this being attributable to the influence of the drift component. The geostrophic part of the ACC exhibits the most significant stability with depth. There is no evidence of a continuous westerly flow at great depths. The ocean in this area can be divided into three layers: surface (to 100-150 m), under the influence of the drift component; intermediate (approximately to 2000 m), in which the correlation coefficients and currents are characterized by maximum stability; deep, where  $r(u)$  and  $r(v)$  change under the influence of bottom relief. Figures 3; references: 5 Russian. [200-5303]

UDC 551.463

#### DISCRIMINATING SYNOPTIC COMPONENT FROM HYDROLOGICAL SURVEY DATA

Moscow OKEANOLOGIYA in Russian Vol 22, No 4, Jul-Aug 82 (manuscript received 8 Jul 80, after revision 16 Dec 81) pp 562-568

NIKITIN, O. P., Institute of Oceanology imeni P. P. Shirshov, USSR Academy of Sciences, Moscow

[Abstract] The author outlines a procedure for discriminating the synoptic component of any scalar hydrophysical parameter on the basis of data from a single hydrological survey. The problem is formulated as follows. The synoptic component (signal) of the field of any scalar hydrophysical parameter  $T$  (such as temperature, density, etc.) is represented in the form of a smooth determined function of coordinates and time  $\bar{T} = \bar{T}(x, y, z, t)$  with a characteristic spatial scale considerably exceeding the mean interval  $h$  of the hydrometeorological survey. The noise component of the  $T$  field, together with the random measurement error, is represented in the form of a random function of coordinates and time  $\Delta T = \Delta T(x, y, z, t)$  with the spatial correlation radius  $r_0 \ll h$ . Assuming that the systematic measurement error can be excluded, each observed  $T$  value is represented by the sum  $T = \bar{T} + \Delta T$ . Denoting the characteristic time scale of the  $\bar{T}$  field by  $\tau$ , it is possible to examine some region of the hydrological survey which contains a number of observations  $N$  adequate for statistical observations with a scatter in time  $\delta t \ll \tau$ . Accordingly, the  $\bar{T}$  field during  $\delta t$  is a function only of coordinates.

The procedure involves a series of successive mean square approximations of the field of the sought-for component by surfaces constructed on the basis of polynomials orthonormalized in a stipulated system of points of a hydrological survey. Proceeding on this basis it is possible to determine the conditions which the separating surface must satisfy. The application of this procedure for reconstructing the synoptic temperature on the basis of data from hydrological surveys in the POLYMODE polygon was described by O. P. Nikitin, et al. in OCEAN MODELING, No 35, pp 12-15, 1980. References: 2 Russian, 3 Western. [200-5303]

UDC 551.465(262:261)

#### MEDITERRANEAN WATERS IN CENTRAL ATLANTIC

Moscow OKEANOLOGIYA in Russian Vol 22, No 4, Jul-Aug 82 (manuscript received 28 May 81) after revision 9 Sep 81) pp 569-572

PLAKHIN, Ye. A. and SMIRNOV, V. G., Institute of Oceanology imeni P. P. Shirshov, USSR Academy of Sciences, Moscow

[Abstract] Measurements of Mediterranean Sea waters were made along the path of their propagation into the central part of the Atlantic Ocean. Computations of stability parameters were made, providing evidence of a seemingly inexplicable presence of virtually untransformed Mediterranean waters in the investigated area. This anomalous phenomenon has been observed in the general area 30°00' N, 30°00' W during observations aboard the "Ernst Krenkel", "G. Ushakov" and "Akademik Kurchatov" in different years. All these observations indicated the presence of a "core" of waters which with respect to their T, S characteristics are quite close to their absolute values in the Gulf of Cadiz. An explanation was sought by an analysis of the fluctuations of flow of Mediterranean waters through the Strait of Gibraltar, providing clear evidence that the discharge of Mediterranean waters at times can vary by a factor of 6. Intensive water exchange in the strait is subject to considerable brief variations. The observed anomaly may also be attributable to the bottom topography effect. The observation region is situated between bottom rises on three sides at the depths of the observed intrusion. It is postulated that the transformation of Mediterranean waters due to the effects of lateral mixing in this region with complex bottom relief transpires less intensively than elsewhere. Figures 3, tables 2; references 6: 3 Russian, 3 Western. [200-5303]

INCREASING EFFICIENCY OF USE OF SELF-CONTAINED SAMPLERS IN GEOLOGICAL WORK  
IN OCEAN

Moscow OKEANOLOGIYA in Russian Vol 22, No 4, Jul-Aug 82 (manuscript received 27 Nov 80) pp 665-670

KONTAR', Ye. A. and GARBUZ, Ye. I., Institute of Oceanology imeni P. P. Shirshov, USSR Academy of Sciences, Moscow; All-Union Scientific Research, Planning and Design Institute of Nonferrous Metallurgy and Mining, Moscow

[Abstract] The article gives an analysis of the possibilities of effective use of self-contained samplers when carrying out geological investigations in abyssal regions of the world ocean. A review of experience with use of such apparatus indicates that a further increase in the effectiveness of employment of such apparatus requires an optimization of the "ballast-buoyancy" system and some other systems and an improvement in the method for deep-water sampling. The first part of this paper gives a theoretical validation of these conclusions. Specific formulas are derived which can be employed in solving the problem of improving design and changing work methodology. Experimental checking of the proposals for optimizing the sampler "ballast-buoyancy" system was carried out by in situ investigations of the working parameters of AP-6000 self-contained samplers. The work was done in the Baltic and Black Seas at depths from 30 to 1500 m and in the Atlantic and Pacific Oceans to a maximum depth of 5300 m. The experimental data made it possible to evaluate the velocity characteristics of this sampler with a change in the rate of its vertical movement from 0.5 to 2 m·sec<sup>-1</sup>. The evaluation was used in optimizing its parameters with respect to the mean rate of its vertical movement with a constant weight of the ballast and different buoyancies. This made it possible to increase the mean rate of its vertical movement. It was found that the hydrodynamic drag of the sampler can be considerably reduced by its streamlining. The use of radio beacons made it possible to register the time of surfacing of the sampler with an accuracy to 6 minutes. A study was made to ascertain the dependence of the duration of the sampling cycle on the depth where the work was done. The drift of the samplers from the points of their release was computed. The average time required for taking an individual sample from a depth of 4500-500 m was found to be 3.5 hours, which is regarded as highly inefficient. It is therefore proposed that samplers be released along a profile or in a closed circuit in such a way that after their release the ship returns to the initial point of sampling at the time of surfacing of the first sampler; this can reduce the total time expenditures by a factor of 4 in comparison with the taking of individual samples. Figures 4, tables 2; references 5: 3 Russian, 2 Western. [200-5303]



## EVALUATING CONCENTRATION OF SUSPENDED SEA MATTER USING LASER ANEMOMETER

Moscow OKEANOLOGIYA in Russian Vol 22, No 4, Jul-Aug 82 (manuscript received 8 Dec 80, after revision 29 Oct 81) pp 671-674

BUNIMOVICH, L. A. and KUDIN, A. M., Institute of Oceanology imeni P. O. Shirskov, USSR Academy of Sciences, Moscow

[Abstract] A laser Doppler anemometer was used to determine the concentration of particles of natural suspended matter in sea water during the 24th voyage of the research ship "Dmitriy Mendeleev" in 1980 in the equatorial part of the Pacific Ocean. At the same time a microscopic analysis was made of these water samples. A standard LDA was employed, with immediate processing of data using a shipboard computer. The particle concentration was computed using a specially prepared program. Individual analytical procedures and the overall algorithm are described. The results of determination of the particle concentration at a particular equatorial station are given. A comparison is made between the analyzed LDA data and the results of microscopic analysis by the standard method. The estimates of the concentration of marine suspended matter obtained using the microscopic and optical methods were closer to one another than in earlier published investigations. The particle concentration determined with the LDA always exceeded (by as much as 1-1 1/2 order of magnitude) the concentration estimate obtained by microscopic investigations. This is attributable to the fact that the latter method is not capable of registering fine particles constituting the bulk of suspended matter in the ocean. The investigations clearly indicate that the laser Doppler anemometer can be used in estimating the particle concentration in sea water. Tables 1; references 8: 5 Russian, 3 Western.  
[200-5303]

## TERRESTRIAL GEOPHYSICS

### GEOPHYSICAL METHODS IN OIL AND GAS PROSPECTING

Moscow PRAVDA in Russian 4 Aug 82 p 2

[Article by G. Flerov, academician, chairman, USSR Academy of Sciences Scientific Council on Application of Nuclear Physics Methods in Related Fields, Hero of Socialist Labor: "Satellites Into the Depths of the Earth"]

[Text] Man is penetrating deeper and deeper within our planet in the search for mineral resources. In its complexity this work is comparable to the mastery of space. It is not without reason that the term "geospace" is being used more and more frequently. Geophysical methods for investigating deep and superdeep boreholes are assuming a decisive place in the search for, exploration and monitoring of the development of deposits, especially of petroleum and gas. Indeed, these are the information "windows" through which it is possible to "see," to be sure, by the use of geophysical instruments, the structure and properties of the earth's crust. A factor complicating such underground "vision" is that the measurement instruments must be of a limited size, they must have very great resistance to thermal and pressure stresses and vibration, and they must ensure the transmission of information on the sections of boreholes from depths of several kilometers. That is why they are frequently called "underground satellites."

The problems to be solved by the "underground satellites" are particularly complex in the search for, exploration and development of petroleum and gas deposits when it is necessary to investigate the properties of rocks and seek these highly important types of minerals through the shields formed by the metal casings of boreholes. In order to study the tens of thousands of such boreholes it was necessary to create fundamentally new geophysical methods for which the metal layer would constitute no interference in the investigation of geological media.

For this purpose the scientists of the All-Union Scientific Research Institute of Nuclear Geophysics and Geochemistry, USSR Ministry of Geology, in collaboration with the institutes of the USSR Academy of Sciences, Ministry of Education, Ministry of the Petroleum Industry, Ministry of the Gas Industry and other departments, in a short time have developed the physical principles of the methods and techniques for sounding the zone around the borehole with a flux either of neutrons or acoustic energy in a relatively broad band of intensities and frequencies.

As a result of the careful theoretical and experimental investigations it was possible to study the patterns of distribution of neutron and acoustic fields in porous rock media containing petroleum and gas and clarify a series of fundamental physical effects associated with the interaction between these fields and solid-liquid media. Methods were created for the use of neutronometry and geoacoustics in order to differentiate rocks containing petroleum and gas from water-bearing rocks, to distinguish impermeable and nonporous strata from strata containing pores, fissures and caverns, that is, to find potential collectors of petroleum and gas. It was necessary to learn to make a quantitative evaluation of such microvoids.

All this required the development of special radiation sources and detectors. Soviet scientists for the first time in world practice designed and industry mastered the production of miniaturized accelerators with a yield up to a billion neutrons per second and wide-band acoustic sources with a diameter of the housings of the borehole instruments of only 90-42 mm, capable of operating at temperatures up to 150 degrees Celsius and pressures up to 800 kilograms per square centimeter. Solutions were obtained for complex physico-technical problems related to the placement in small deep apparatus of accelerators of ions, power sources with a voltage of more than 100,000 V, detectors of nuclear radiation and other devices which usually are large apparatuses of the laboratory type.

The industrial testing and introduction of the developed methods took place in the most important petroleum regions of our country with the creative cooperation of scientists with production organizations in Tatariya, the Ukraine, Azerbaijan, Siberia and Kazakhstan.

As a result a number of fundamentally new technological procedures have been proposed for searching for, exploring and developing petroleum and gas deposits. Thus came about the direction of reexploration or review of the already existing cased boreholes for the detection of earlier missed horizons in the upper parts of geological sections, including exploited deposits. The possibility of systematic monitoring of the course of working of petroleum-bearing strata through observation and operational boreholes also appeared.

It is easy to understand that the detection of new deposits (strata) within the limits of already worked deposits and careful monitoring of the extraction of petroleum will lengthen the time that they can be exploited. There is no need to drill additional boreholes, which will reduce by several times the cost of exploration. The petroleum workers of Tatariya, using these geophysical methods, began to seek out and put into operation sectors of deposits where the effectiveness of petroleum extraction was low. Finally, a new technology appeared for the search for, exploration and reckoning of the reserves of petroleum and gas under highly complex geological conditions, already associated with the geophysical monitoring of strata.

Usually the mastery of fundamentally new technologies meets with significant organizational complexities. Here, however, the production organizations of the USSR Ministry of Geology and union republics, Ministry of the Petroleum Industry and Ministry of the Gas Industry have "put their shoulders to the wheel." Rapid and effective introduction has been favored by the bringing

together of the efforts of party and administrative agencies on the site. I would particularly like to note the participation of the Tatar and Mangyshlak party oblast committees. As a result of the smooth working together of the body of scientists and production workers the progressive technologies in a short time were effectively implemented at the Samotlorskoye, Fedorovskoye, Romashkinskoye, Zhetybayskoye, Uzen'skoye, Urengoyskoye, Orenburgskoye, Astrakhanskoye and other deposits. The economic effect achieved due to the application of the nuclear physics and geoacoustic methods and apparatus exceeded 80 million rubles.

All this gives basis for assuming that the work of the body of scientists at the All-Union Scientific Research Institute of Nuclear Geophysics and Geochemistry and production organizations on the "creation and introduction in the national economy of highly informative pulsed methods for wide-band acoustic and neutron logging for upgrading the effectiveness in search for, exploration and working of petroleum and gas deposits" will rightfully be proposed for award of the USSR State Prize.

5303

CSO: 1865/202

## COMMENTARY ON 'MASSA' EXPERIMENT

Moscow PRAVDA in Russian 30 Nov 82 p 6

[Article by A. Gorokhov, PRAVDA special correspondent]

[Text] The scientists of the Institute of Physics of the Earth imeni O. Yu. Shmidt have completed an analysis of the results of a multisided experiment for exciting the earth's ionosphere and magnetosphere by means of a surface explosion of moderate intensity. The experiment, in whose implementation 15 Soviet scientific research organizations participated, was carried out within the framework of the so-called MASSA program.

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The letters MASSA represent an abbreviation of "Magnetospheric-Atmospheric Relationships During Seismoacoustic Phenomena" (Magnitosferno-Atmosfernyye Svyazi pri Seysmo-Akusticheskikh Yavleniyakh). Even a nonspecialist will probably understand that scientists have now 'zeroed-in' on the investigation of such a highly complex system as "earth's crust - atmosphere - ionosphere - earth's magnetosphere" -- which for the time being cannot be reduced to a mathematical description. An artificial earthquake was selected as the singular triggering mechanism in the method for modifying this system, a ground explosion being used for this purpose.

The MASSA experiment without exaggeration can be called a victory of Soviet geophysics. It is not only that there is a great number of participating research personnel. The ionosphere can be regarded as a dish reflecting the radio waves sent from the earth. This reflects the modern points of view concerning circum-terrestrial space as a natural laboratory whose modeling under "normal" conditions is simply impossible, but where, on the one hand, using the modern surface and satellite arsenal, it is possible to carry out very precise experiments.

The silent and void cosmic world seemingly lives a surprising life. The earth is surrounded by a gigantic envelope of plasma, held by the planet's magnetic field. There are many disturbers of the calm of this ocean, the sun being the most important of these. Not much need occur on the sun and immediately there is a change in the parameters of the solar wind blowing around the earth -- streams of plasma and corpuscular radiation. The ionosphere, as a sensitive tuning fork, responds to the solar flares. The echoes of these disturbances

roll toward us, for example, in the form of auroras, disruptions of radio communication, and other phenomena which specialists in the field of solar-terrestrial relationships are striving to understand and foresee. It is a surprising fact that space is even able to "speak." Once the author had an opportunity to hear a magnetic recording of these "conversations," reconstructed in the frequency range audible to the human ear: whistlers, hisses, choruses... This is the multivoiced space ocean, carrying solar energy to the earth on its waves.

However, our planet also acts on its electric envelope. Let's say that a volcano is "triggered" on Kamchatka and somewhere in the western hemisphere there is a disruption of radio communication. Or on earth a bright flare is observed on the sun, rising in the form of a facula and accompanied by noise. Scientists refer to this phenomenon as a "warning" luminescence. In addition, Soviet (especially the "Intercosmos-19") and American ionospheric satellites have registered ionospheric disturbances over the epicenters of future earthquakes.

"The diversity of phenomena associated with processes in the earth's crust, atmosphere, ionosphere and magnetosphere, even in the example of earthquakes only, has induced us to turn to a so-called active experiment," says Professor M. Gokhberg, doctor of physical and mathematical sciences, deputy director of the Institute of Physics of the Earth. "It would be attractive, to be sure, to construct a hypothetical electromagnetic model of an earthquake focus, but here for the time being many things are unclear. Nevertheless, we should analyze what effects in circumterrestrial space can be related to acoustic disturbances, discriminate them or identify them with the effect of electromagnetic fields..."

Here it is fitting to mention that controllable (active) experiments in the ionosphere, carried out by Soviet and foreign scientists during the last 15 years, in particular, by specialists of the Space Research Institute, USSR Academy of Sciences, have opened up a fundamentally new stage in the study of space. They can be classified into two types. The first type includes experiments not changing the qualitative state of the investigated medium, such as the use of "tagged" atoms. An example of this is the Soviet-French ARAKS program, involving the injection of low-intensity electron beams in the ionosphere from aboard a rocket with an electron gun-injector, or the creation of so-called barium clouds. The second group includes artificial disturbances, such as by the use of radio radiation or the injection of powerful electron and ion beams into the electric ocean surrounding the planet. True, the energy of such effects is nevertheless inadequate for the generation of appreciable effects in the magnetosphere.

As is often the case, nature suggested the answer: why, by the use of a powerful surface explosion, not attempt to model atmospheric disturbances similar to those which accompany earthquakes or the eruption of volcanoes and in this way trace the behavior of the ionosphere and magnetosphere?

"We have attempted to carry out a 'pure' experiment," explains one of the participants in the MASSA program, O. Pokhotelov, doctor of physical and mathematical sciences. "Indeed, volcanoes and earthquakes give much 'mud', in the

literal and figurative sense of the word, and a study was made of the effect of an acoustic wave on the ionosphere in pure form..."

Exactly a year ago, in the steppe to the north of Alma-Ata, about 300 tons of explosives were brought in and the necessary net of observation stations was organized. Then an explosion thundered. The people who had set up the experiment took care that this moment coincided with the flight of the Soviet-French satellite "Oreal-3." Five minutes after the explosion the front of the acoustic wave, carrying a considerable energy, attained an altitude of 100 km. A disturbance developed in the lower layer of the ionosphere, disrupting the propagation of radio waves at distances up to several hundreds of kilometers from the site of the shot. And after two or three minutes the ionosphere was again disturbed, which was noted on the ionograms of the observation stations situated, in particular, at Frunze and at Irkutsk.

Scientists, by means of a satellite, could register secondary radiation which was generated in the ionosphere as a result of artificial modification from the earth. A purely geophysical application of the MASSA project is an attempt to construct an electromagnetic model of an earthquake focus. But the acoustic wave propagating through the atmosphere, in addition to practical fields, has led scientists into the field of fundamental problems. How are acoustic waves from the earth transformed into electromagnetic disturbances of different types? Further experiments and detailed theoretical investigations will answer this question.

5303

CSO: 1865/44

## POSSIBLE SYSTEMATIC ERRORS IN OVM INSTRUMENTS

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 266, No 4, Oct 82  
(manuscript received 24 May 82) pp 827-829

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[Abstract] Specialists at the Central Scientific Research Institute of Geodesy, Aerial Mapping and Cartography have developed the OVM and "Agat" pendulum instruments. Experience in their use has shown that in accuracy and convenience in work they surpass all others in use. At the same time, an instrument called the GABL (absolute ballistic laser gravimeter) has been developed at the Institute of Automation and Electrometry, Siberian Department, USSR Academy of Sciences. Joint measurements have revealed that with respect to accuracy and stability of the results the GABL is probably one of the best absolute instruments in use. With the GABL the absolute gravity value can be determined with a mean square error of about  $\pm 6-8 \mu \text{ gal}$ . Since the OVM systematic errors cannot be determined except by comparison of the same parameters measured with instruments whose design is based on fundamentally different physical laws, it was decided to make parallel measurements with the OVM and GABL. This was done at several stations in the IGSN-71 system: Moscow, Potsdam, Port Moresby, Hobart and Sydney. This made it possible to form 4 differences  $\Delta g$  measured with the OVM and GABL. The results of measurements of these differences are tabulated: weighted and simple means are given. The scale factors are also given. The discrepancies in the values of the  $\Delta g$  differences measured with the two instruments are small, but there were significant differences between the weighted mean and simple mean of the scale factor. However, serious problems may arise in measuring large  $\Delta g$ . Within USSR this effect in determining  $\Delta g$  between the extreme northern and southern points can lead to systematic errors greater than 0.12 mgal. In order to solve the problem of the need of calibrating pendulum instruments, especially when used for determining large  $\Delta g$ , it is desirable that both instruments be used in measuring  $\Delta g$  between extreme points in the north and south of the USSR. Tables 1; references 5: 2 Russian, 3 Western.  
[13-5303]



## SEARCH FOR BIOLOGICAL PRECURSORS OF NAZARBEKSKOYE EARTHQUAKE

Tashkent UZBEKSKIY GEOLOGICHESKIY ZHURNAL in Russian No 2, Mar-Apr 82  
(manuscript received 3 May 81) pp 37-40

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[Abstract] Few studies have been made of the biological precursors of earthquakes. Studies of this type initiated after the Tashkent earthquake of 26 April 1966 were not followed up. New observations have been made and preliminary results are given. An earthquake with a magnitude of 5.5 and a force at the epicenter of about 8 scale units occurred near Nazarbek village in Tashkentskaya Oblast on 11 December 1980. The hypocenter was at a distance of 10 km. A study was made of the possibility of manifestation of biological precursors of this earthquake. This was done by consultation of the records of emergency medical services, seeking to determine whether the seismic event was preceded by any anomalous deviations in health of the local population. In the first stage of the study an investigation was made of the number of emergency calls without allowance for specific causes. It was found that the incidence of diseases of children increased significantly, but unfortunately the time of the earthquake coincided with the maximum incidence of colds and flu. A similar study was made for adults, but this was also indefinite. In the second stage of the study an attempt was made to determine the number of emergency calls as a function of distance to the epicenter. It was anticipated that the greatest number of cases would be registered for the nearest-in station and the fewest for the farthest-out station and this was in fact the case. In the third stage of the study an effort was made to obtain data for individual diseases (cardiovascular cases, nervous system afflictions and psychoses). For psychoses the peak fell on 5 December 1980, being the highest for a three-month period. For the nervous system, on the other hand, there was some dropoff. Thus, there may be a prognostically anomalous change in the number of diseases prior to earthquakes. However, in this investigation no study was made of changes in climatic conditions, periodicity in the appearance of various diseases and other variables. Figures 1; references:

3 Russian.

[43-5303]

## PLANETARY AND REGIONAL CHARACTERISTICS OF MANTLE STRUCTURE ON BASIS OF PS EXCHANGE WAVE OBSERVATIONS

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 266, No 2, Sep 82  
(manuscript received 4 Apr 82) pp 313-316

VINNIK, L. P., AVETISYAN, R. A. and MIKHAYLOVA, N. G., Institute of Physics of Earth imeni O. Yu. Shmidt, USSR Academy of Sciences, Moscow

[Abstract] Mantle-formed PS waves have been discriminated on long-period records in Norway and at Obninsk. Now similar records have been obtained for a series of seismic stations in the United States (ALQ, DUG, GOL, TUC). Whereas the European stations are on the East European Platform, the American stations are in an area with an activated upper mantle. A comparative study was made of the depth  $h$  and structure of seismic discontinuities in the transition zone. The  $h$  values were estimated earlier on the basis of refracted P waves. Data indicate the possibility of lateral  $h$  variations in the range of several tens of kilometers. Interpretation of the P waves shows that the uncertainty of the  $h$  values is  $\sim 100$  km. Observations of the PS phases make it possible to ascertain  $h$  and the structure of the transitions virtually independently of the estimates obtained by the refracted waves method. For each station from 12 to 14 records were obtained in the epicentral range from  $38$  to  $11^\circ$ . The results of these American observations are discussed in detail. They indicate a pronounced horizontal inhomogeneity of the transition zone with a scale of several hundreds of kilometers. A wave having  $h \sim 640$  km and reliably discriminated on the records for TUC and in Europe is absent on the DUG records. In order to explain the DUG observations it must be postulated that the transition zone there is a gradient layer with a thickness of not less than 100 km without a sharp discontinuity, whereas in Norway, for example, the transition has the nature of a gradient layer with a thickness of 50 km, underlain by a sharp discontinuity. A distinct anomaly of the transition zone is located under ALQ, where a single extremely intensive phase is discriminated having  $h \sim 510$  km. A wave with  $h \sim 400$  km is discriminated unreliably and a wave having  $h \sim 640$  km is not detected at all. It is possible that the increase in velocity usually concentrated at 640 km is concentrated at 510 km. The nature of the anomaly requires special study. (This work was done under the Soviet-American program for the prediction of earthquakes.) Figures 2; references 15: 3 Russian, 12 Western.

[12-5303]

## ASSOCIATION OF MAXIMUM EARTHQUAKES IN PACIFIC OCEAN RING WITH DISCRETE LATITUDES

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 265, No 4, Aug 82  
(manuscript received 2 Mar 82) pp 840-844

GUBERMAN, Sh. A., Institute of Applied Mathematics imeni M. V. Kaldysh,  
USSR Academy of Sciences, Moscow

[Abstract] The author has devoted several earlier studies to the D-waves hypothesis (VYCHISLIT. SEYSMOL., No 12, p 158, 1979; DAN, Vol 257, No 6, 1981). In this hypothesis it is assumed that if a strong earthquake occurs at a certain latitude it indicates that two D-waves have met at this latitude and it is this event which has triggered the event. It is postulated that the epicenters of very strong earthquakes are associated with discrete D latitudes  $90^\circ \cdot i/2^n$  ( $i = 1, 2, \dots, 2^n - 1$ ), with the exponent  $n$  not exceeding 5, usually being  $\leq 4$ . In this new investigation the author seeks to eliminate a number of ambiguities in his earlier work, the objective being a further validation of his thesis. The earth's surface was divided into latitude zones, the axis of each being one of the D-latitudes with  $n \leq 4$ , the width of each zone being equal and with each zone intersecting one or more seismically active regions. Emphasis here is on the Pacific Ocean seismic ring, characterized by many earthquakes with  $M_S \geq 8.0$  -  $M_S \geq 7.0$ . USCGS catalogue data for 1897-1977 were used, revealing that the considered seismic ring occupies 23 latitude zones corresponding to D-latitudes with  $n \leq 4$ . It is striking that in 19 of the 23 zones the maximum earthquake is no more distant from the D-latitude than  $1^\circ$ . In the case of earthquakes with  $M_S \geq 8.0$ , 19 of 20 meet this test for a D-latitude with  $n \leq 4$ . It was felt necessary to test the hypothesis using the H. Kanamori magnitude scale  $M_w$ , rather than  $M_S$ . Using this criterion it was found that in 24 of 33 regions in maximum earthquakes with  $M_S \geq 8.0$  fall at D-latitudes with  $n \leq 4$ . It was necessary to account for the other nine. The final conclusion is drawn that in the Pacific Ocean seismic ring 74% of the events with  $M_S \geq 8.0$  fall within  $1^\circ$  of D-latitudes with  $n \leq 4$ , whereas the others fall at D-latitudes with  $n \sim 5$ . Figures 1, tables 2; references 7: 2 Russian, 5 Western.

[203-5303]

UDC 550.834.32(99.15)

## DEEP SEISMIC INVESTIGATIONS IN WESTERN ANTARCTICA

Novosibirsk GEOLOGIYA I GEOFIZIKA in Russian No 9, Sep 82 (manuscript received 19 Feb 82) pp 110-118

PETRIK, G. V., SERGEYEV, V. N., KOGAN, A. L. and VASIL'YEV, V. P., Sevmorgeo, Leningrad; Irkutskgeofizika; Institute of Geology and Geophysics, Siberian Department, USSR Academy of Sciences

[Abstract] Deep seismic investigations by the method of point soundings with the "Tayga" telecontrolled apparatus were carried out during 1979-1980 during

the work of the 25th Soviet Antarctic Expedition over an extensive area of the southern coast of the Weddell Sea, the Filchner and Ronne Ice Shelves and surrounding areas. The principal tasks were the perfecting of procedures for field investigations in the high latitudes, registry of the wave field, its analysis and construction of a seismic section of the crust and top of the mantle. The investigated profile has a sublatitudinal direction and passes approximately 60 km to the south of the Soviet seasonal base "Druzhnaya." The profile was chosen because gravimetric and magnetometric data indicated that the area was characterized by a thick sedimentary cover, a system of grabens and tectonic dislocations, thus being a region differing essentially from those studied earlier in geomorphological and geological respects. The profile ran completely within the limits of the Filchner Ice Shelf, which in large part is afloat. Since the glacier surface is accessible only by air, a helicopter was used for transport purposes. The main peculiarity in use of the "Tayga" was that work had to be done at around-the-clock negative temperatures. The first deep seismic investigations confirmed the high effectiveness of the differential soundings method and the "Tayga" apparatus. It was possible to perfect procedures and determine the conditions for carrying out field work under the complex climatic and geomorphological conditions in Antarctica. Within the limits of the profile intersecting the Filchner Ice Shelf it was possible to register and analyze the wave field associated with regionally expressed seismic discontinuities. A seismic section was constructed which reveals the major features of structure of the crust and top of the mantle. The thickness of the sedimentary cover varies from 2-3 to 12-14 km (from east to west). Locally it was possible to break down the sediments into strata. The mean velocity in the earth's crust (6.3 km/sec) has values characteristic for continental regions. This experience in carrying out deep seismic investigations in the zone of the Antarctic shelf is also useful in studying other shelf zones, including polar seas. Figures 4; references: 8 Russian.

[24-5303]

UDC 550.837

# MAGNETOTELLURIC SOUNDING OF CONDUCTING ZONES IN EARTH'S CRUST AND UPPER MANTLE

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ZEMLI in Russian No 7, Jul 82  
(manuscript received 2 Jul 81) pp 55-68

BERDICHEVSKIY, M. N., DMITRIYEV, V. I., BARASHKOV, I. S., MERSHCHIKOVA, N. A. and KOBZOVA, V. M., Moscow State University imeni M. V. Lomonosov; Institute of Applied Problems in Mathematics and Mechanics, UkSSR Academy of Sciences

[Abstract] The authors discuss different aspects of the resolution of deep magnetotelluric sounding in relation to local conducting zones in the earth's crust and upper mantle. The analysis indicated that crystalline rocks screen local conducting zones and that the resolution of magnetotelluric sounding can

in actuality be much lower than in a one-dimensional model. A review of past experience clearly indicates that the features most favorable for deep magnetotelluric sounding are prominences of the basement, rock complexes with well-developed extrusive formations and platforms with a high-resistivity cover. It is concluded that the use of one-dimensional models is probably acceptable when investigating crustal conducting zones. In studying asthenospheric zonality there may be difficulties associated with the low resolution of magnetotelluric sounding and the inadequacy of one-dimensional models. There is a need for critical evaluation of the real possibilities of deep magnetotelluric sounding. An interpretation using models with a one-dimensional distribution of deep conductivity can lead to very serious errors, increasing the depth of the conducting zone and decreasing its total longitudinal conductivity. If the region is intersected by deep faults through where there is a conductive redistribution of the current, the resolution of magnetotelluric sounding is increased and the region of applicability of one-dimensional models is broadened. (This problem remains virtually unstudied and it would be premature to draw practical conclusions.) It is believed that substantial progress can be made if magnetovariation profiling is used for detecting and outlining asthenospheric zones and the quantitative interpretation of magnetotelluric curves is accomplished using two- and three-dimensional models. Figures 8, tables 4; references 20: 13 Russian, 7 Western. [22-5303]

UDC 550.343.6

# SPATIAL-TEMPORAL CHANGES IN $V_p/V_s$ FIELD BEFORE STRONG EARTHQUAKES ALONG SHORES OF KAMCHATKA

Moscow VULKANOLOGIYA I SEYSMOLOGIYA in Russian No 4, Jul-Aug 82  
(manuscript received 6 Apr 81) pp 84-95

SLAVINA, L. B., Institute of Physics of Earth, USSR Academy of Sciences

[Abstract] Studies of the  $V_p/V_s$  parameter on Kamchatka were initiated in 1971. The results for the first five years have been published; this article gives the results for the entire observation period. It was found that the distribution of regions of decreased and increased  $\sum [\Delta V_p/V_s]$  values does not remain fixed in space and time. Several months prior to a strong earthquake in the region of a future focus on Kamchatka there is an intensification of local minima which are formed in the course of a number of years before it. The appearance of spatially localized anomalies and also zones of high gradients according to data for a number of stations situated in different azimuths can serve as a prognostic criterion for evaluating the site and time of strong earthquakes. The sign of the anomaly is dependent on the relative location of the foci of weak earthquake and stations relative to the focus of a future strong earthquake. Anomalous regions, according to data from stations situated in mutually perpendicular directions relative to a future earthquake, have an opposite sign. It can be assumed that the field of the ratio of velocities carries information on the field of stresses and changes of this

ratio with time and in area are related to changes in the stress field prior to a strong earthquake. As a result of these observations over a prolonged period of time it was possible to detect regions with a stable spatial positioning of anomalies of different sign. For example, there are three zones for which a steep-gradient nature of the field persists over a long period of time. These zones, on the basis of the retrospective analysis presented in this article, can be regarded as potential zones of the occurrence of strong earthquakes with  $M \geq 7$ . Figures 5, tables 1; references: 4 Russian. [19-5303]

UDC 550.341.5

#### EARTHQUAKE PREDICTION FROM CHANGE IN CONDUCTIVITY OF ROCKS

Moscow VULKANOLOGIYA I SEYSMOLOGIYA in Russian No 4, Jul-Aug 82  
(manuscript received 4 May 81) pp 96-99

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[Abstract] Structural failures begin in rocks when elastic stresses attain the breaking point of rocks. This results in a change in the pore space and filling of this space with fluid, this causing a change in rock conductivity. Observations have been based on the assumption that the greatest structural dislocations develop in the focal region of an impending earthquake. The authors feel that the conductivity effect has not become a reliable precursor of earthquakes due to the observation method itself. Because of the complexity of the deep sounding method resistivity measurements have been made infrequently and in most cases the critical 10-day period prior to a tremor has not been covered by observations. In addition, there are other shortcomings, such as a lack of knowledge concerning the site of the impending earthquake. Only by covering an extensive region would it be possible to ensure any degree of success. Accordingly, a different method is proposed for observing the change in rock resistivity. It is also based on the concept of an increase in rock fissuring and porosity prior to a tremor, but not in the focal region, instead in the surface layer of the earth's crust. In this method rock resistivity is measured in the water-bearing horizon along a horizontal profile of several hundred meters. The electrodes used were the casings of boreholes drilled to the water-bearing horizon. Another variant of the method involves resistivity measurements along a vertical profile from the water-bearing horizon to the surface. In this modification one electrode was buried in the ground 1.5-2 m, whereas the second was the casing of a borehole penetrating the water-bearing horizon and 200-400 m distant from the first electrode. Such investigations suggest that the conductivity of rocks in the surface layer of the crust changes prior to earthquakes with a sign opposite the change in the focal region. These observations were made in the Kurile Islands. The preliminary conclusion is drawn that several days before an earthquake of a definite force

and at definite epicentral distances there is an increase in the resistivity of rocks in the surface layer. It is still difficult to evaluate fully the properties and effectiveness of this precursor. The proposed method is incomparably more effective than the method based on changes in resistivity in the focal region. Figures 1; references 9: 8 Russian, 1 Western.  
[19-5303]

SURFACE WAVE GENERATION BY MOVING SOURCE

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian  
Vol 18, No 8, Aug 82 (manuscript received 15 Jan 81, after revision 18 May 81)  
pp 887-889

GONCHAROV, V. P. and PAVLOV, V. I., Institute of Atmospheric Physics, USSR  
Academy of Sciences

[Abstract] Many studies have been devoted to the radiation of waves by a moving source, but here the authors obtain specific results for a model and formulate an approach to such problems on the basis of the Hamiltonian formalism method. In the basic formulation of the problem it is assumed that a source moves with a constant velocity  $v$  parallel to the discontinuity of two media. A Cartesian coordinate system is introduced and it is assumed that there are different media on the two sides of the undisturbed discontinuity: the lower half-space is filled with a homogeneous incompressible fluid and the upper half-space is filled with an ideal gas. The analysis can be made using the results of an earlier study (Goncharov, V. P., "Wave Interactions in the Ocean-Atmosphere System Within the Framework of the Hamiltonian Formalism Method," IZV. AN SSSR: FAO, Vol 16, No 5, pp 473, 482, 1980). An equation is first derived for describing motion of the medium which takes into account the discrete modes corresponding to acoustic and internal gravitational waves. This makes it possible to characterize the spectral density of the radiation energy of the corresponding waves in a unit time. Separate computations are made for surface and internal gravitational waves. An expression is given for computing the radiation intensity of surface waves. Intensity is examined as a function of height and velocity. Similar computations made for internal waves revealed that the contribution to radiation from surface waves is small in comparison with the contribution from internal gravitational waves. Figures 1; references: 2 Russian.

[5-5303]



## EVALUATING RELATIVE CONTRIBUTION OF SCATTERED ATMOSPHERIC RADIATION TO RADIATION FLUX MEASURED IN SOLAR DIRECTION

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian  
Vol 18, No 8, Aug 82 (manuscript received 1 Apr 81) pp 882-884

PROKHOROV, V. M., Leningrad State University

[Abstract] In investigating the gas and aerosol components of the atmosphere it is common to use the Bouguer method, employing the radiation flux in the direction of the sun. It is usually assumed that the scattered radiation is an insignificant part of the total radiation flux registered by the instrument. However, for photometers with an angle of view  $10^\circ$  the error in determining the optical thickness of the atmosphere due to the contribution of scattered radiation attains approximately 10% in the spectral range 336-956 nm. For this reason the author has estimated the relative contribution of multiply scattered radiation to the total solar radiation flux measured at the earth's surface with different values of the radiation detector solid angle. The atmosphere is represented in the form of a layer of finite optical thickness having plane symmetry and bounded from below by a surface reflecting in accordance with Lambert's law. With these and other stipulations a study is made for two cases: when the lower boundary of the layer is at sea level and when the lower boundary of the layer is at 3 km; the reflection coefficient for the underlying surface was assumed equal to 0, 0.2 and 0.8. An investigation of the problem in this formulation indicated that only with values of the solid angle of the radiation detector  $\Delta\omega < 2$  is there a significant contribution of diffuse radiation to the total flux of solar radiation incident on a detector oriented perpendicular to the direction to the sun and the relative error in determining the optical thickness of the atmosphere by the Bouguer method does not exceed 1%. Tables 2; references 10: 5 Russian, 5 Western.  
[5-5303]

## COLLAPSE OF REGIONS OF MIXED IONOSPHERIC GAS

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian  
Vol 18, No 8, Aug 82 (manuscript received 3 Jul 80, after revision 22 Feb 82)  
pp 879-882

ZHMUR, V. V., Institute of Oceanology, USSR Academy of Sciences

[Abstract] Experimental studies of the propagation of gravitational waves in the upper layers of the atmosphere have shown that at the altitudes of the E, D, F layers waves can have considerable velocities. At these same altitudes tides have velocities greater than 100 m/sec and waves with velocities up to

600 m/sec have been registered. The tides create a considerable shear. This can result in instability, wave collapse and subsequent turbulence. In this way conditions can be created in the ionosphere for the existence of volumes of mixed gas. The author here endeavors to describe the last stage in the dissipation of such spots because the first two stages evidently are similar to collapse in the ocean and atmosphere. The materials in this article confirm the existence of spots of mixed gas at ionospheric altitudes. In the main thickness of the ionosphere the dynamics of such spots virtually does not differ from the dynamics of spots in the neutral atmosphere because electromagnetic effects exert an influence when there are adequate thicknesses of the mixed layers. This makes it possible to apply the theory of spot development in the neutral atmosphere and ocean to the ionosphere. At altitudes of 130-140 km on solarly active days in addition to the three traditional stages in collapse there can also be a stage of ion slowing in which spot dissipation is impeded for the most part by the ponderomotive force. The stage, however, is brief and the spot rapidly reaches the stage of viscous outflow. Figures 2; references: 10 Russian. [5-5303]

UDC 551.596.1:534.222.2

#### ATTENUATION OF WEAK SHOCK WAVE IN ISOTHERMIC ATMOSPHERE WITH ALLOWANCE FOR DISPERSION CORRECTION

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian Vol 18, No 8, Aug 82 (manuscript received 13 Jul 81) pp 797-803

URALOV, A. M., Siberian Division, USSR Academy of Sciences; Siberian Institute of Terrestrial Magnetism, Ionosphere and Radio Wave Propagation

[Abstract] This article gives an example of computations of the propagation of a gas-dynamic shock wave with a small amplitude and a short duration in the isothermic atmosphere. In the solution the wave equation is linear with constant coefficients since the dispersion of an unbounded medium is considered. The initially fixed disturbance experience dispersion with formation of a tail. In the approximation of nonlinear acoustics it is necessary to find a correction for the law of attenuation of a weak shock wave; it is assumed that this correction is small, but this correction increases with time. In this case the shock wave attenuates more rapidly and the compression phase profile is not triangular. In the shock front region there is a constant leakage of energy into the tail part. Two cases of the propagation of a gas-dynamic shock wave of short duration in an isothermic atmosphere are examined: a) upward propagation, which occurs, for example, during an earthquake tremor; b) during downward propagation, when the wave attenuates rapidly. Figures 1; references: 6 Russian. [5-5303]

## MEASURING TIDAL VARIATIONS OF ATMOSPHERIC PRESSURE AND THEIR CORRELATION WITH GEOMAGNETIC DISTURBANCES

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian  
Vol 18, No 10, Oct 82 (manuscript received 11 Sep 81) pp 1098-1101

BYCHKOV, V. S., Water Problems Institute, USSR Academy of Sciences

[Abstract] The author gives the results of synchronous experimental measurements of fluctuations of atmospheric pressure and variations of the variable geomagnetic field in the diurnal range of periods. Measurements of fluctuations of atmospheric pressure were made using a Bobrov microbarograph with a response 0.03 mb/mm and a Bobrov quartz variometer with a response 0.1  $\gamma$ /mm, all measurements being made at sea level. The data consisted of a 45-day record from Cuba, a 45-day record for the Isle of Pines, a 4-month record for the Caspian Sea, and a 1-month record for the Black Sea, a total of 242 observation days. The mean periods of fluctuations of atmospheric pressure and geomagnetic variations fell in the range from 11 to 24 hours. It is emphasized that the data were obtained to the south of the Tropic of Cancer, a region where the described atmospheric processes differ considerably from similar processes registered poleward. A spectral analysis was made under a program based on the Fourier fast transform method with a high-frequency filter. The analysis revealed statistically significant intensity peaks in periods of 12 and 24 hours. If the atmospheric pressure has two statistically significant peaks in 12 and 24 hours, geomagnetic variations also have two corresponding peaks; if atmospheric pressure has one peak in 24 hours, geomagnetic variations also have one statistically significant peak in 24 hours. On the other hand, if in atmospheric pressure there is dominance of a 12-hour oscillation, in geomagnetic variations with two peaks there is always a dominance of a 24-hour oscillation, although there is also a statistically significant peak for 12 hours. It is clear that in the considered cases in the tidal periods there is an identity of oscillations of the neutral atmosphere and ionosphere. It is postulated that considerable tidal winds in the lower atmosphere can be propagated upward to the ionospheric layers. Even in a case when the tidal movement in the lower atmosphere has a semidiurnal character, its characteristics are reflected in geomagnetic variations, ensuring the existence of a statistically significant intensity peak in a 12-hour period with a peak of dominating intensity in 24 hours. Figures 2, tables 2; references: 7 Russian.  
[17-5303]

## ENERGETICS OF LOWER THERMOSPHERE IN PRESENCE OF INTERNAL GRAVITATIONAL WAVES

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian  
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pp 1095-1098

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[Abstract] On the basis of data obtained by spectroscopic thermometry at the level of the mesopause during periods of appearance of internal gravitational waves it was possible to estimate the  $\mathcal{E}$  and  $K_z$  (rate of generation of turbulent energy and coefficient of vertical exchange) values for these altitudes. In addition, an estimate was made of the contribution of the turbulence generated by decaying internal gravitational waves to the thermal regime of layers in the lower thermosphere. Quasistationary conditions were assumed. It was found that measurement of temperature by an optical method in three regions of the sky is adequate not only for the registry of internal gravitational waves, but also for evaluating the intensity of turbulence in the upper atmosphere. The coefficient of vertical turbulent exchange can be estimated by measuring the temperature field in the atmosphere at an altitude  $h_0 \approx 90$  km. The turbulence not only leads to intensive mixing of the atmospheric components, but also exerts an influence on the thermal regime of the upper atmosphere. Two competing processes are involved: the atmosphere is heated due to the viscous dissipation of turbulent eddies and is cooled as a result of work against negative buoyancy forces (in the case of a stable stratification). The rates of heating and cooling are estimated. The evaluation of the contribution of turbulence (associated with decaying internal gravitational waves) to the energetics of the lower thermosphere, made by two methods, indicates an insignificant role of the latter to the overall energy balance. Data from optical thermometry show that allowance must be made for other heat sources and losses, especially the presence of such admixtures as  $\text{CO}_2$ , CO and  $\text{H}_2\text{O}$ , but this complex problem is not dealt with in this article. Tables 1; references 7: 6 Russian, 1 Western.  
[17-5303]

## EFFECT OF ANOMALOUS DISPERSION ON ATMOSPHERIC AEROSOL COMPONENTS OF MINERAL ORIGIN

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[Abstract] Until recently it has been assumed that in the IR region the spectral properties of the atmosphere could be fully explained on the basis of molecular absorption by vapor and gas components and that the presence of aerosol particles can be neglected. There has been accumulating evidence that this question requires full review, particularly with respect to that part of the aerosol consisting of particles of mineral origin whose matter has a region of anomalous dispersion in the IR range. Accordingly, the authors made both a theoretical and experimental study of this anomalous dispersion phenomenon. Applicable to the region 0.5-15  $\mu\text{m}$  the Mie theory was used in determining the attenuation spectra for such aerosol components as silicon oxide and dioxide, aluminum oxide, calcium carbonate, magnesium oxide, sodium chloride and soot. The formula used was

$$\alpha(\lambda) = N \int_0^{\infty} \pi r^2 K_0(\rho, m, \lambda) f(r) dr,$$

where  $\alpha(\lambda)$  is the aerosol attenuation coefficient,  $N$  is the volumetric concentration of particles,  $K_0$  is the attenuation efficiency factor,  $\rho$  is the Mie parameter,  $m$  is the complex refractive index of particle matter,  $f(r)$  is the particle-size distribution function,  $r$  is particle size. Computations of the complex refractive index were made in the single scattering approximation for monodisperse fractions with particle sizes 0.5, 1.0, 3.0, 5.0, 5.0, 10  $\mu\text{m}$  and polydisperse media whose particle-size distribution is stipulated in the form of gamma functions. It was found that there are transmission bands in the region of anomalous dispersion of matter dependent to an insignificant degree on variations in the disperse composition of aerosol. The position of the transmission bands and their width are dependent on particle size (assuming a given value of the complex refractive index); under the same conditions the maximum of the transmission band is displaced in the direction of short wavelengths and the width increases. All computations were then experimentally checked in a special chamber, the results being compared in a table and figures. It is shown that three of the transmission bands in aerosols with maxima 4.3, 9.6 and 12  $\mu\text{m}$  coincide with atmospheric transparency windows and the very existence of these windows is associated both with the presence of transmission bands in the absorption spectra of vapor and gas components and the existence of the anomalous dispersion effect on aerosol components of mineral origin. Figures 4, tables 1; references 10: 7 Russian, 3 Western.  
[203-5303]

## RADIATION ATTENUATION OF ACOUSTIC-GRAVITATIONAL WAVES IN NONISOTHERMIC ATMOSPHERE

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSPHERY I OKEANA in Russian  
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[Abstract] The author gives an analysis of the radiational attenuation of acoustic-gravitational waves in an atmosphere with an arbitrary vertical temperature profile. A Newtonian approximation is used, since the atmosphere to altitudes 70 km is in local thermodynamic equilibrium, radiational attenuation can be investigated using the equations of hydrodynamics and radiation transfer. On this basis an approximate WCB solution is obtained. The solution is obtained in an isothermic atmosphere with an exponential distribution of absorbing matter. The attenuation coefficients are examined in depth. Both fast and slow acoustic-gravitational waves are considered. The range of applicability of the WCB approximation is considered in detail. Numerical evaluations of the relative role of attenuation of radiation are presented and the conditions under which radiational attenuation predominates are defined. It is concluded that internal gravitational waves, except for the highest frequency waves, attenuate for the most part due to the radiational mechanism, whereas acoustic waves, other than low-frequency waves, attenuate due to viscosity. With increasing altitude the role of viscous attenuation increases, whereas the role of radiational attenuation decreases. In the real atmosphere the WCB method can be used in studying the attenuation of acoustic-gravitational waves caused by molecular and turbulent viscosity and heat conductivity and other mechanisms. References 13: 10 Russian, 3 Western. [17-5303]

## COMBINED ACOUSTIC AND RADIOACOUSTIC SOUNDING OF ATMOSPHERIC BOUNDARY LAYER

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[Abstract] Specialists at the Institute of Atmospheric Physics have developed a combined acoustic sounding-radioacoustic sounding system operating in the decimeter range for obtaining an adequately full range of data on the vertical structure of the lower troposphere and its dynamics. The different parameters which can be determined with this system are discussed (as well as the method for measuring them): temperature, standard deviation of temperature;

structural characteristics of temperature fluctuations; vertical component of wind velocity; standard deviation of vertical component of wind velocity; rate of dissipation of turbulent energy. The apparatus used is a monostatic sodar with a single transmitting-receiving antenna and an accompanying radar with transmitting and receiving antennas placed symmetrically relative to the sodar. The apparatus operates at a radio wavelength of 30 cm and an acoustic wavelength 15 cm with a radar power of about 5 W and an acoustic power of the sodar 6 W. Vertical resolution for the radioacoustic sounder is 34 m, whereas for the acoustic sounder it is 17 m. A block diagram is given with 27 components identified; its principle of operation is discussed in the text. Experimental use in the summer and autumn of 1980 is discussed in detail. The test revealed the possibility of simultaneous remote measurement of a number of the fundamental parameters of the atmosphere characterizing stratification and the turbulent regime of the boundary layer. In order to analyze the vertical distribution of thermal turbulence in inversions it would be necessary to use synchronous data on the wind velocity profiles. Figures 3; references 19: 14 Russian, 5 Western.  
[17-5303]

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# EVALUATING INFLUENCE OF SCATTERING INDICATRIX ON MEAN LENGTHS OF PHOTON PATHS IN CLOUDS

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian  
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[Abstract] A detailed study was made of the influence of the scattering indicatrix form on the mean path lengths of photons. In comparison with earlier studies, there has been a broadening of the number of model cloud situations and the indicatrices  $Y(\varphi)$  for three parts of the spectrum ( $\lambda = 0.7, 3.0, 10.0 \mu\text{m}$ ) have been included. The distribution of photons by paths  $w(\ell)$  and the mean lengths of paths  $\ell_{\text{mean}}$  were computed by the Monte Carlo method. The problem was formulated as follows. Over an infinite plane orthotropic surface with the albedo  $A$  there is an infinitely extended layer of a scattering medium with a thickness of 1 km. A slightly scattering interval between the cloud layer and the underlying surface had a thickness of 1 km; the albedo of the underlying surface was  $A = 0, 0.2, 0.8$ , which approximately corresponded to reflection from a sea surface, grass cover and snow. Three indicatrices were selected for the scattering cloud layer. With these and other conditions taken into account, it was demonstrated that the form of the scattering indicatrix, which is determined primarily by the part of the spectrum, exerts an influence on the mean lengths of photon paths in clouds, although for the model situations considered in this article this influence does not exceed 30-40%. Figures 3, tables 1; references: 7 Russian.  
[17-5303]

EXPERIMENTAL EVALUATION OF SOME COEFFICIENTS OF SIMILARITY FORMULAS FOR  
LAGRANGIAN TURBULENCE CHARACTERISTICS IN ATMOSPHERIC SURFACE LAYER

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian  
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[Abstract] A new contribution has been made to use of the theory of dimensionalities and similarity for describing turbulent diffusion of an impurity in the atmospheric surface layer. The author describes the behavior of particles in the atmospheric surface layer on the basis of tetron data. Individual tetroons were tracked. This made it possible to obtain the distribution moments of all three coordinates of the tetroons without any additional hypotheses. In the article measurements of the first moments of the coordinates and velocities were used in determining some empirical constants which are compared with theoretical evaluations. Movements of the tetroons in time and space were registered with a stereophotogrammetric apparatus. The tetroons were released simultaneously in twos or threes, the initial distance between them being 5 m. The time interval between them was 30-60 sec, depending on the experimental conditions. The survey was made each 2.65, 3 or 5 sec, depending on mean wind velocity. The duration of photographing of the tetroons did not exceed 500 sec and was dependent on wind velocity and direction relative to the photographic base, atmospheric stability conditions, illumination and background brightness. The absolute errors in measuring tetron coordinates increase with increasing distance from the photographic base. With cameras having a focal length  $f = 100$  mm and a photographic base 100 m the absolute errors in measuring coordinates at a distance of 1000 m are  $m_x = 0.71$ ,  $m_y = 0.28$ ,  $m_z = 0.13$  m. In 7 experiments the temperature stratification was neutral or nearly neutral, in 5 -- unstable and in 3 -- stable. The experimental data confirmed some corollaries of the hypothesis of similarity of the Lagrangian characteristics of turbulence in the atmospheric surface layer and made it possible to obtain experimental evaluations of a number of important constants. Figures 6, tables 2; references 14: 7 Russian, 7 Western.  
[5-5303]

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